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JULIUS VON SACHS.

A BIOGRAPHICAL SKETCH: WITH PORTRAIT.

F. NOLL.

[In the preparation of this sketch for the BOTANICAL GAZETTE, Dr. Noll concluded that the very full one which he had prepared for *Naturwissenchaftliche Rundschau*, and which appeared in the issues of September 4 and 11 (1897) of that journal, had better be translated and abridged. This has been done by John G. Coulter.—EDS.]

ON May 29, 1897, death released from a long struggle with a hopeless illness a man who, in the fullness of his power, had left a permanent impress upon research in vegetable physiology. In the history of physiology his name will be inseparably connected with an epoch of great advance, of exact investigation, and of extension of physiological study into all structure.

Julius Sachs, the third son of Graveur Sachs, was born at Breslau, October 2, 1832.[1] The quiet family life was largely spent in the country, and the awakening mind of Sachs was early directed toward the observation of nature. With passionate zeal he collected all obtainable plant forms, pressed,

[1] In my statements regarding the family, I am dependent upon the material which the younger daughter of Dr. Sachs, Fraulein Marie Sachs, has kindly placed at my disposal. I am especially indebted also to Professor F. Cohn, Professor Goebel, Professor Körnicke, Professor Nobbe, Professor Strasburger, and Ministerial-Director Dr. H. Thiel, for their invaluable assistance.

identified, and even cultivated them, without, however, losing all the lively interest of a boy in other amusements.

Near the town house of the Sachs at Breslau there stood in a large garden a small one-storied structure, insignificant from without, and much restricted within. From this unpretentious building, however, there was exerted upon the scientific world without a mighty influence, and from this place there went out young men inspired by the zeal of an exact, experimental investigator, and pledged to enrich the store of biological knowledge. That little house was the laboratory of the famous physiologist Purkinje.. It was, perhaps, the first place where exact physiological experiments were successfully performed. In this garden young Sachs was the playmate of the two sons of Purkinje. They were three keen and enthusiastic observers with a common and absorbing interest in nature. Purkinje, who, in addition to his studies in animal physiology, occupied himself to some extent with botanical investigations, very soon recognized the gifts of young Sachs, and aroused in him an active interest in the work of the laboratory. At this time, besides Sachs, there were others at work in the Purkinje laboratory who later became noteworthy botanists. Among these were Ferd. Cohn and N. Pringsheim.

At about this time heavy misfortune fell to the lot of the Sachs family. In 1848 an apoplectic stroke killed the father, and scarcely a year later cholera took from the seventeen-year-old boy his mother and a brother. Not yet out of the gymnasium, young Sachs was thrown wholly upon his own resources. With new determination he continued his work at sketches, lithographs, and painting, and sought thereby to sustain himself at his studies. That was no easy task, however, and already the young man, with his characteristic determination, had decided to become a sailor, when Purkinje, who had meanwhile accepted a call to Prague, afforded him an opportunity to come there. Sachs was received as a son into the Purkinje house at Prague. He was enabled to complete his interrupted course at the Gymnasium, and meanwhile assisted Purkinje, and had much to do

with the making of illustrative wall charts, and with microscopical work. Purkinje, a keen investigator, with a talent for geniality and cordiality, responsive in his contact with young people, must have been in his domestic life a strong master, who was a little particular and exacting in his methods of training. Sachs, who in his young years was certainly accustomed to work and privation, has repeatedly made mention of the "harte Arbeit" with which he had to make recompense for the privilege of his sojourn at the Purkinje establishment. In order to satisfy all the demands which were made upon him, it became necessary for him to reinforce his often exhausted nerves with artificial stimulants, whose use, learned here, finally became fatal to the never resting man.

Having successfully passed the entrance examinations, Sachs was admitted as a student at the University of Prague in 1851. For a short time he attended the lectures of the botanist, Kosteletzky, and later those of Willkomm. He occupied himself somewhat with physics and mathematics, but was especially interested in philosophy under the direction of Professor Zimmermann, who won a great influence over the student, and deemed him worthy of a friendship almost paternal. The work which he carried on at the same time in the Purkinje laboratory was limited exclusively to animal physiology.

In Prague, through the influence of Purkinje, Sachs learned Bohemian, and was induced to publish a number of scientific contributions in the Bohemian journal *Živa*, which he signed with a Bohemian name.[2]

In 1855 his name appeared in the *Botanische Zeitung* for the first time in any German scientific journal. The very first contribution of the young investigator, dated 1853, gives evidence of his keen insight. It is his account of *Collema bulbosum* (*pulposa*), in which he discussed the change which he had observed in nostoc colonies growing in Collema, and urged that this "Unwandlung" was caused by the appearance of "gleichsam

[2]A German list of the titles of these publications occurs in the catalogue which is published with Goebel's "Nachruf," Flora, supplementary volume of 1897, p. 126.

parasitischer Pilzfäden" in union with the nostoc. Sachs himself doubtless did not recognize at this time the "Sachverständigen," whose first prophecy he here expressed, and which, later, an exhaustive study was to bring finally to general acceptance. This first presentation, however, is of much historical interest, inasmuch as it describes for the first time the organic interdependence of lichen fungi and algæ. Probably it was the fault of circumstances that this presentation of Sachs was omitted from the "Register," and that this important contribution has been so generally overlooked. Even in the work of Reess, in which sixteen years later the synthesis between the nostoc of Collema and the Collema-hyphæ is noted, no mention is made of the precisely similar observations of Sachs.

In 1856 Sachs received his degree, and a year later separated himself from Purkinje and began to devote himself to the study of plant physiology. To obtain means for living, however, he continued to devote some attention to drawing and to writing. Problems pertaining to seed germination, and the earliest development of plant organs, attracted his attention before all else, and chief among the work undertaken in this first period at Prague was the inauguration of studies upon germination, which even now are having their continuation in the latest observations upon metabolism and "Stoff-wanderung."

In April of 1859, through the solicitation of the zoologist Stein, and upon the recommendation of Hofmeister, Sachs was called to Tharand as an assistant to Professor A. Stöckhardt. When Stöckhardt learned from the friends of Sachs of the water-culture experiments which the latter had begun at Prague, he recommended that the scope of the experiment station at Tharand be extended so that experimental plant physiology might be introduced upon no mean scale, and that the "especially well qualified Dr. Julius Sachs, of Prague" be called to take charge of the new department. And so at Tharand, jointly with Stöckhardt, Sachs carried out that pioneer work of his upon the nourishment of plants studied by means of water-

cultures. A whole series of contributions, appearing for the most part in the *Landw. Versuchs-Stat.*, bear eloquent testimony to his ceaseless activity during the comparatively short sojourn at Tharand.

Early in 1861 Sachs was elected head of the newly created experiment station for plant physiology and docent in plant and animal physiology at Chemnitz, but before he entered definitely upon his duties there, he accepted a call, received in April of the same year, to a professorship in the agricultural academy at Poppelsdorf. Here, at first, he had charge of both plant and animal physiology and mineralogy.

At Poppelsdorf Sachs married an Austrian lady, a talented woman, whose limited income enabled the maintenance of a very modest establishment. At this time Sachs' salary was but 700 thalers.

The laboratories of the investigator were at this time as modest and limited as his domestic establishment. Two very small rooms, and an apartment in the basement, which also served the housemaster for a kitchen, formed the "institute" in which Sachs and his students worked. With them were associated G. Kraus, now professor at Halle, and the honored Dr. Thiel,[3] who is still Ministerial-director of the scientific study of agriculture.

The six years of Sachs' activity at Poppelsdorf were extraordinarily rich in scientific results. Fifteen important contributions upon the germination process, upon metabolism and the translocation of food material, upon the influence of light and temperature changes upon particular phases of vegetation, appeared in the years 1862–1864 alone. His work at this time upon the metamorphosis of food material during the germination and early growth of plants demonstrated the easy control of the method of transforming glucose into starch and the reverse, the transformation from carbohydrates into fats, albu-

[3] In simple but telling words, full of sincere feeling, this old and true friend of Sachs, at the semi-centennial jubilee of the Academy, told of all those old homely conditions which surrounded the epoch making work of the dead investigator.

minous bodies, etc., and the method of their translocation in the plant body. Although his experiments upon these problems were conducted with the assistance only of the very crude methods of microscopical technique then in vogue, despite our vastly improved methods we are scarcely able to repeat them. But, according to Sachs' own words, the most important outcome of this work was the idea which it prompted, that he must seek the true organs of assimilation in the chlorophyll bodies, a theory which Sachs stated first hypothetically, yet precisely, and which later was established by him through exhaustive research.

Besides these numerous and important contributions there appeared also during the time of his activity as a teacher and investigator at Poppelsdorf the *Handbook of experimental plant physiology*, being part of a general treatise which, at Sachs' suggestion, came out in four volumes, edited by Hofmeister in conjunction with De Bary, Irmisch, Pringsheim, and Sachs. Although Sachs' particular field of physiology has not been the most worked since, the part which he contributed to the *Handbook* is today the best known and most read. On account of its clear method of presentation, and its wealth of striking observations, it yet serves as a valuable source of information. Few of the many observations and suggestions which Sachs made here, with so free a mind, and with such remarkable insight, have been followed up since either by himself or others. The exact physical and mathematical studies of his undergraduate days, the excellent training he had had from Purkinje in the manipulation of physiological experiments, and his remarkably clear and complete method of exposition, united to give to this, his first work of importance, so rare a value that the young docent, known hitherto only for his undaunted energy and manly beauty, gained at once a place of recognition in the world of learning. In humorous vein he once described for me the wonderful "Umschwung" which the appearance of the *Handbook* had gained him.

When De Bary, in the spring of 1867, resigned his chair at Freiburg, Sachs was called to it, and one year later he succeeded

Schenk at Würzburg. Here, where the administration was in fullest accord with the desires of the great investigator, and where he received fullest recognition, Sachs remained thirty years, always hard at work.

During his professorship at Würzburg, Professor Sachs declined calls to high positions at Jena, Heidelberg, Vienna, Dorpat, Berlin, Bonn, and Munich. At Würzburg a great building, which had originally served to house a pharmacological institute, was placed entirely at his disposal for the uses of the botanical institute, since become famous throughout the botanical world, and inseparably associated with the name of its founder. Here were assembled rich collections, excellent contrivances for teaching, and instruments without number, all of which bear eloquent testimony to the emphasis which its director laid upon instruction as well as investigation. "Give your chief attention to your lectures" he wrote to me at Bonn in this connection. "Regard the activity of a professor in the way of publication as a thing of much value for its own sake, and the results as things not to be overlooked, yet always bear in mind that the professor is primarily a teacher." In his laboratory Sachs gathered about him a group of young botanists chosen from the whole scientific world, and the "Arbeiten" of the institute became the recognized authority upon physiological research. Baranetsky, Brefeld, F. Darwin, Detlefsen, Dufour, Elfving, Gardiner, Godlewski, Goebel, Hansen, Hauptfleisch, Heinricher, Klebs, Miliarakis, Millardet, Moll, Müller-Thurgau, Nagamatsz, Pfeffer, Prantl, Reinke, Scott, Stahl, Frau Professor Tarnowski, Vines, H. de Vries, Marshall Ward, Woronin, Wortmann, Zimmermann, and other botanists of renown, have worked at the institute under Sachs' direction.

Only to those who possessed, like himself, the "heilige Ernst" of their subjects were the privileges of the Institute extended. It was hedged about with such rigid restrictions that those who sought the world-renowned establishment for less commendable purposes were distinctly discouraged. Whoever neglected his work, his apparatus, or his plant-cultures (upon plant-cultures

Sachs laid a special emphasis) even once without valid excuse might be perfectly confident that he would find his place occupied by another. There was always a considerable waiting list for entry into the institute. Sachs took only a limited number (ten) of workers into his laboratory, and for my own first appointment as supernumerary in the famous establishment, I have wholly to thank a warm recommendation from Herr Kölliker.

In the first year of his residence in Würzburg, 1868, there appeared the first edition of the well-known *Lehrbuch*, upon which Sachs had begun definite work almost immediately after the appearance of the *Handbuch*, and which was the fruit of years of previous labor in Poppelsdorf and Freiburg. The same evidences of superiority which had already characterized the *Handbook* appeared in yet higher degree in the later volume. Its presentation and general grasp, as well as the vast amount of preliminary research which the work of the author represented, gave the new work a rank which heretofore had never been attained by any text-book of botany. It was a masterpiece of presentation in text and illustration alike, and not only set forth in clear and critical fashion the facts of plant-life which came within its scope, but presented to a considerable extent theories, unworked problems, and the prophecy of future fields which made it invaluable to botanical research. Even more than the presentation and material of the text, the admirable illustrations gave to the work an excellence not yet surpassed. Today we still meet in nearly all botanical texts these excellent old familiar figures of Sachs. Only two years after the appearance of the first edition of the *Lehrbuch*, a second became necessary, and two years later a third, and in 1874 the fourth appeared. In its translated form this book extended the most recent botanical knowledge and the thought of the modern scientific world into all the lands of culture, and it served the interests of physiological investigation and stimulated general botanical interest in a way which heretofore had been denied any botanical work. According to the testimony of my Ameri-

can friends and colleagues, the *Lehrbuch* has worked wonders in the United States.[4]

It is characteristic of the painstaking and thorough nature of his work that Sachs could never bring himself to permit the appearance of a fifth edition of a book which had been so rapidly prepared. "It had become no longer the expression of my ideas," he writes in the preface to his *Lectures upon Plant Physiology*, in referring to the *Lehrbuch*. The *Lehrbuch*, however, had become the court of last appeal in matters of botanical discussion in its particular field, having been more quoted as an authority than any other botanical work.

To the ripened mind of Sachs there had come to be no longer any pleasure in the mere assembling of facts and critical references, which had been necessary in the preparation of the *Lehrbuch*. His artistic nature had prompted the thought that he had a greater work to do in the way of cultivating that feeling toward nature which is so conspicuously lacking in the majority, and which he regarded as essential. With this thought, he devoted himself to the development of a work which was to contain the whole of his botanical grasp and conviction. This was the origin of his *Vorlesungen*, which yet remains the foundation of all investigation in plant physiology. Perfect in its pleasant and vigorous style of presentation, possessing the charm of keen and comprehensive observation, this remarkable work added to these qualities evidences of a master's ideas of artistic work.

A man of a definite and decidedly original conception of things in general, Sachs was able none the less to regard fairly all subjects from other standpoints than his own, a quality which brought him into thorough sympathy with many other fields of work. In one of his lectures he said: "You shall know the process of reasoning whereby your lecturer has formed the mental picture of the field of science which is his personal belief. Your acceptance of it, however, is quite another thing, and

[4] See Professor Arthur's address before the American Association for the Advancement of Science, 1895. Proc. A. A. A. S., 7, 9, 15, 17, 18. 1895.

whether I am more nearly right than others is a matter which does not enter into the present discussion." The intended function of the *Vorlesungen* was the clear display of a comprehensive picture, confused as little as possible by the universally known facts of plant physiology, and "without the toilsome ballast of apparatus-description, which should be contained in any handbook or text-book published for the profession." Even in the preface to the *Lectures* there is betrayed to the thoughtful observer and psychologist that fine artistic gift possessed by one who was also the keenest and most analytic of investigators.

Whoever has had the good fortune to have been intimately associated with Sachs must have noticed the artistic side of his nature. As a boy he was thoroughly instructed by his father in sketching and in painting. A little later, as the student of the younger Purkinje, a highly gifted painter, he became farther imbued with artistic ideas, and as a student at Prague we find him not only upon the benches of the "Hörsäle," but even zealously engaged in the studio work of the Painters' School. Whoever has seen the large and handsome wall-charts which Sachs used in illustration of his lectures, and which he himself prepared, and has watched the rapid and energetic brush work of a hand as fleet as it was sure, must grant that this genial investigator had the ability of a great artist, and might have achieved fame in the world of art.[5]

How very deeply his artistic nature imprinted itself upon his investigations, and influenced his presentation, is expressed in some words which I have found among his unpublished papers:

> With me it has seemed of great importance, and, indeed, has always been a leading thought running through my scientific work, that I should make science as much as possible a work of art, and endeavor in all my publications to use artistic standards in the presentation of the truths of nature. There have been for me, since I began to think independently, no boundary lines between art and nature, and through the course of years I am coming more and more to regard this unity the single goal of my thought. For this

[5] I recall very clearly how once he had painted a green plant entirely red, and answered my astonished inquiry with the words: "Do you mean that you are unable to detect the red which is in the leaf-green?"

reason every kind of controversy has become distasteful to me, for it gains nothing for progress.

With the idea that it should not be a continuation of the *Lehrbuch*, which had already served but to give a practical insight into the subjects discussed, work on the *Vorlesungen* went on until it had attained a bulk almost too great. Sachs' practical appreciation of the difficulties of his students, and his thoughtfulness for them impelled him to publish with Prantl an abridged edition of the *Lehrbuch*, but later Goebel published the systematic part of the earlier *Lehrbuch* as supplementary to the *Vorlesungen*.

As the result of historical investigation, a critical work far different from that which occupied his chief attention, appeared in 1875, the *History of Botany* from the sixteenth century up to 1860. This work formed the fifteenth volume of an historical series published by the Royal Academy of Sciences of Munich, under the patronage of Maximilian II. Sachs' contribution was a departure from any method which had heretofore been employed in the presentation of the history of botany. His material was not arranged according to authors, nor was it presented chronologically. In this history there again appears evidence of that spirit which never let him feel satisfied until he had made out the entire significance of his facts, their mutual interdependence, and the influences which acted upon the development of botanical study. With his clear presentation of confusing facts, he also furnishes to the reader his own well-founded judgment upon the relative value of different periods. In the preface he wrote:

> I have conceived as my chief task to discover the first awakening of scientific thought, and to follow its later development through comprehensive theories; this is my estimate of the true history of a science. . . . . I have placed here in the foreground as the real makers of our history those men who not only established new facts, but contributed fruitful thoughts as well.

In our judgment, the work of Sachs has been powerful in the construction of what we have called "building material," and he is in the first rank of "geistige" creators. We see him in the last years of his life keen as ever in his scientific contributions,

which appeared in the *Works of the Botanical Institute of Würzburg;* and all the time he was successfully engaged in many fields of work, much devoted to the development of new methods and to the contrivance of apparatus, always adding new "Bausteine," that here the edifice of botanical knowledge might be brought to a harmonious completion, and there new foundations might be laid for later superstructure.

And yet, as though in early youth life's bitterest portions had not already been his, he must even in his declining days keep up a hard and bitter struggle for existence. Body and soul, he was during the whole of his life ardently devoted to his work. From four or five o'clock in the morning until late into the night he was at his researches. In his zealous devotion to his work and to his family he blinded himself to the fatal results of the use of the drug to which he had frequent recourse for stimulation. Yet, what Goethe said of his own life, Sachs could say of his, and in full truth, "It was the constant turning of a stone which ever presented itself anew. The annals of my life are ended when that is said. I have too much credit for my activity. It was correlated with my existence."

Sachs was not only a botanist, he was a philosopher in the best sense. His keen and just regard for his own science was lessened no whit by his relation to art and politics and history. The world had for him the same charms and beauties it had for Goethe. Let these words of Goethe be my final tribute to him who was my master and my friend, to whose fatherly regard the warmest feelings of my heart respond:

If he was one who stood apart from the world, let it be called well, for the world can be served best by those who are not of it.

BONN, GERMANY.

NOTES ON THE EUPHORBIAS OF DR. EDWARD PALMER'S DURANGO (MEXICO) COLLECTION OF 1896.

CHARLES F. MILLSPAUGH.

THE following notes, based upon Dr. Edward Palmer's 1896 collection from the neighborhood of the city of Durango, Mexico, while offering but little in the line of novelties, will serve to emphasize the necessity of closer study into the relationship of species in the extensive and intricate genus Euphorbia.

Upon continual comparison of the various species, I have become more than ever convinced that the general habit gives but little insight to true specific character, especially in the Anisophyllæ, and that it is in the seeds only that absolute constancy of character exists. These seeds, minute as they are, retain their specific character even when the general characters of the plant become radically changed by the environment. In regard to the involucres, little can be determined by them except by careful and complete dissection and evisceration of the tubal envelope, the walls and appendages of which only then exhibit their true characters. It would appear that in the typical Euphorbia there are five glands in alternation with five involucral lobes; thus wherever one or more glands are absent in a species some rudiment of these organs remains. This is indicated by the five heavier veins or bands of thickened tissue that lead up from the pedicel to these appendages. While the lobes of the involucre, that play so serious a part in the fructification of the ovule, are constant in their character, the glands and their rudiments, being accessories only, vary much with the habitat and environment of the individual.

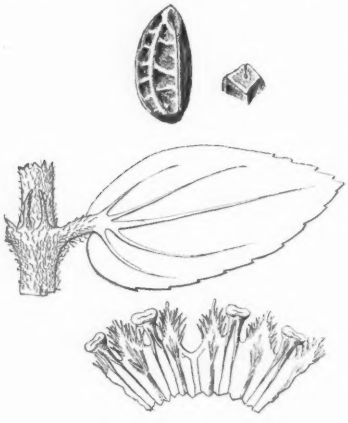
In any series of species the size variation is so great that no specific scale of drawing can be profitably maintained, nor would the invariable application of such scale be of practical value.

Therefore, in the cuts accompanying the species here noted, the opened involucre is diagrammatic, and no size relation exists in the magnified seed.

§ ANISOPHYLLUM, *Hypericifoliæ*.

EUPHORBIA PILULIFERA PROCUMBENS (DC.) Boiss. DC. Prod. 15 : 21.

In this form the stipules are linear-lanceolate, a pair on each surface of the stem, the superior pair with an interstipular gland.



As in *E. lineata* the lobes of the involucre are not "fimbriate," but very hairy; the fact that the hairs are as large as those of the branchlets causes them to appear—in comparison with the minute lobes of the involucre—as if they were fimbriæ. The fifth gland is replaced by a deep notch through which passes the recurved stipe of the fruit. The seeds are pinkish, sharply quadrangular, 0.8^{mm} long, 0.4^{mm} broad, the concave facets marked by several transverse ridges, some of which are extended but part way across the facet.

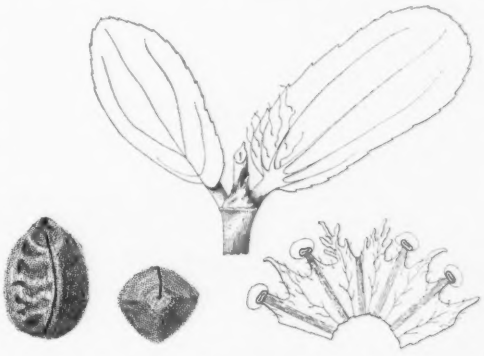
Dr. Palmer's [360 Durango 1896] specimens are the most robust that I have seen. Dr. Schott's Yucatan 56 and 57 are much smaller plants, although the leaves and involucres are of the same size as those in Dr. Palmer's form. Dr. Gaumer's Yucatan 315 is a counterpart of those of Dr. Schott, but his 1003 seems to be a transition to the species itself. Dr. Ridell's Key West 1839 is the same as the Schott Yucatan form, while Valdez Yucatan 2 is very near Dr. Palmer's Durango plants.

EUPHORBIA PRESLII Guss. Fl. Sic. Prod. 1 : 539.

The various forms of this species throughout its range readily account for its frequent confusion with *E. hypericifolia* L. I

have an exact counterpart of Dr. Palmer's 206 Durango in a specimen collected by myself at Waverly, N. Y.; this form has all the leaves large, broad, and lurid. His Durango 894 (similar but with pale green leaves) is duplicated in H. N. Patterson's Oquawka (Ill.) form; while his Durango 900, with its slender and strongly falcate leaves, has its counterpart in Addison Brown's Rhinebeck (N. Y.) and W. C. Werner's Painesville (Ohio) plants. These are all very evident *E. Preslii*, but in a large number of forms from Rio Janeiro to Canada the macroscopic differentiation between this species and *E. hypericifolia* is almost impossible, as the erect or prostrate growth, the smooth or hairy branches, the full or part serration of the leaves, the fimbriation or ciliation of the triangular or lanceolate stipules, the presence or absence of a red spot on the leaves, the size or shape of the glandular appendages or lobes, and the depth of the sulcus bifurcating the styles, intermixes both species in these characters; however, the seed stands out clear and definite in them all, that of *E. Preslii* being ovoid and black, and having a prominent lighter dorsal angle.

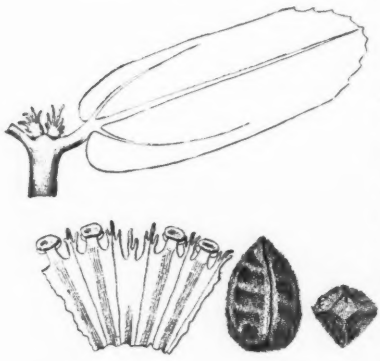
The special characters of this species are as follows: Glandular appendages manifest and entire, the fifth gland replaced by a shallow sulcus flanked on each side by larger and lacerate involucral lobes, the other three lobes being entire and triangular. The seeds are ovoid, black, with somewhat ashen angles, 1.3^{mm} long and 0.8^{mm} broad; the ventral surface is strongly convex, the dorsal triangular with a prominent central ridge rendering the whole sub-quadrangular, the several partly anastomosing transverse ridges on each facet being



slight and ashen. In this and the related species, *E. hypericifolia*, *E. nutans*, *E. lasiocarpa*, and *E. Braziliensis*, there exists a minute black caruncle that appears to have escaped the attention of the authors of the species.

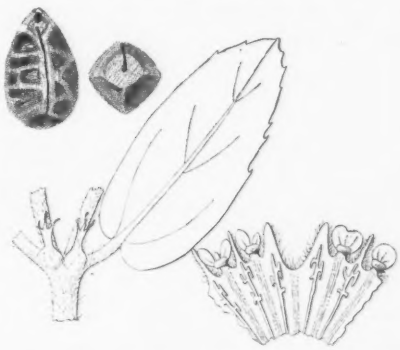
EUPHORBIA NUTANS Lag.? Gen. et. Sp. nov. 17.

In Dr. Palmer's 226 Durango we find a form that answers exactly to Lagasca's species, so far as his meager description gives the characters of his plant. In the absence of his type, I cannot do better than to accept, as a basis of differentiation between it and *E. Preslii*, his "floribus axillaribus solitariis," which cannot possibly mean any known form of the glomerate flowered *E. Preslii*. Lagasca says: "Caule patulo dichotomo villoso: ramis apice floriferis nutantibus: foliis ovato-oblongis subcordatis obsolete serratis: floribus axillaribus solitariis," to each and every character of which Dr. Palmer's plant agrees, except mayhap the "villoso," a character never determinative or constant in any plant. Taking this form, therefore, to answer to *E. nutans* Lag., I add the following to the original description: *Caule patulo dichotomo villoso* at the extremities of the branches only, *ramis apice floriferis*, the upper angulate, the lower striate, the stems terete; *foliis ovato-oblongis subcordatis obsolete serratis* at the apex, 3-nerved; stipules interpetiolar, triangular, long fimbriate-ciliate; *floribus axillaribus solitariis*, involucres small, turbinate, long pediceled; lobes lanceolate, 3 to 4-irregular-fimbriate, glands 4, small, ovate, appendages little more than a sarcous dorsal ridge upon the stipe of each gland, fifth gland replaced by a 2-fimbriate smaller involucral lobe; capsule glabrous, carpels obtuse; seeds ashen-black, the transverse rugæ more prominent than in *E. Preslii*, the ventral suture extending from the caruncle downward, and the dorsal angle sharper.



The determination of this species must be considered provisional.

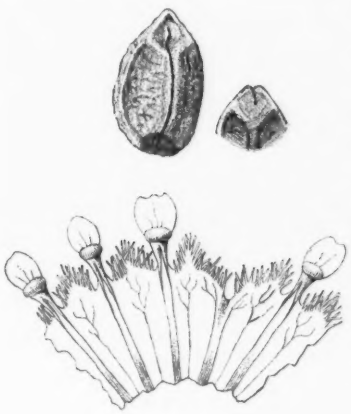
EUPHORBIA LASIOCARPA Klot. Nov. Act. **19**: suppl. 414.



In addition to Boissier's description of this species, in DC. Prod. **15**: 23, might be given the following characters: *Stipulis interpetiol.* roseate beneath, *brevis triangularibus* 2 to 3–fimbriate at the apex. *Semine* brownish red *ovato-quadrangulo*, 1.1^{mm} long, 0.7^{mm} broad, the ventral surface convex, the dorsal triangulo-convex. The anastomosing ridges on facets of this species are much more prominent than in *E. Preslii.* and the angles more obtuse.

Nos. 198 and 199 of my collection (Yucatan Allison V. Armour Exped. 1895) belong to this species, not to *E. hypericifolia* as given in Contrib. **1**: 27, Field Col. Mus. Bot. Dr. Arthur Schott returns the species from Merida, and Dr. Gaumer from Izamal (882), Yucatan

EUPHORBIA LINEATA Watson, Proc. Am. Acad. **21**: 455.



Leaves short petiolate, more crenate than serrate, stipules lanceolate-aristate on the upper side of the branch, lanceolate-fimbriate on the under side. The involucral lobes of the type are not "lacerate" but triangular-hairy, the hairs appearing like lacerations, the glandular appendages are small, oblong entire or 1 to 3-notched at the apex. The fifth gland is represented by a deep sulcus between the two larger involucral

lobes. A distinctive feature in this species is the presence of glands at each bifurcation of the panicled inflorescence, large counterparts of the involucral glands.

Dr. Palmer's 618 Durango specimens differ from the type in their somewhat larger appendages, longer and more hairy petioles, and more robust habit.

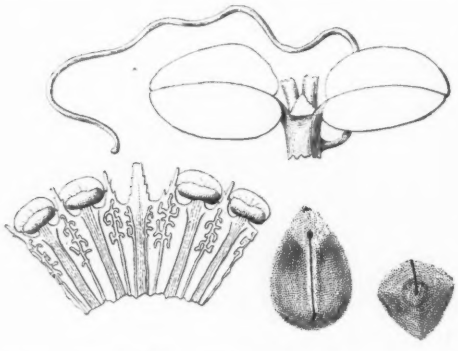
Chamæsyce.

E. SERPENS Kth. H. B. & K. Nov. Gen. et Sp. 2:41.

Dr. Palmer's 42 Durango specimens of this species are very close to var. *radicans*, but the appendages are plainly to be seen. The stipules are interesting, those of the extremities of the branches being roseate and longer than the floral leaves, those of the lower leaves being subtended by a small peltate-stipitate gland or pair of glands, a feature also present in Pringle's 3778 from San Louis Potosi, 1891. Dr. Palmer also returns from Durango (819) a small rosulate-prostate form with minute leaves, and a general roseate color.

EUPHORBIA SERPENS RADICANS (Moric.) Engelm. DC. Prod. 15: 30.

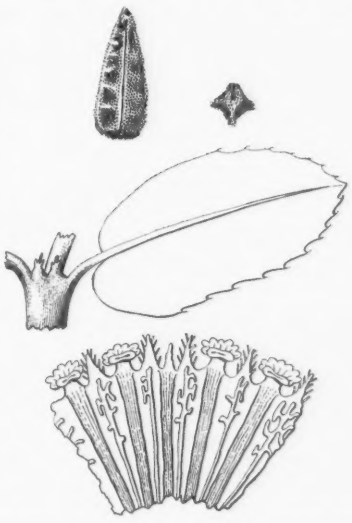
In *E. serpens* and its forms the fifth gland of the involucre is replaced by a truncate serrate lanceolate lobe. The venation of the involucre throughout the *Chamæsyce* is interesting, as by its size and maze-like character it plainly shows this body to be evolved from the leaf, where this venation is continued in an anastomosing network of the same elemental type. The seeds are pink, somewhat pyriform, 0.8^{mm} long, 0.5^{mm} broad, triangular with a convex ventral surface, and sharp dorsal angle.



Dr. Palmer's 296 Durango, fine robust examples, have red-maculate leaves, frequent radication towards the ends of the branchlets, nearly entire (simply erose) stipules and exappendiculate glands. Specimens collected by Dr. Mohr, and Newman in Alabama agree well with Dr. Palmer's, while those of Pammel from Iowa, Eggert from Illinois, Dr. Krause from Missouri, and myself from West Virginia have very evident white or roseate glandular appendages, and fimbriate-margined stipules.

EUPHORBIA PROSTRATA Ait. Hort. Kew. **2**: 139.

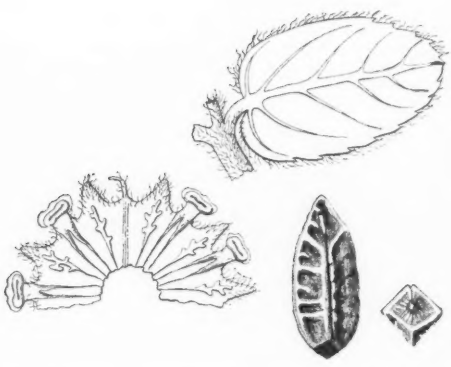
Dr. Palmer's Durango specimens of this species agree with the description of Boissier in DC. Prod. **15**: 47, except in having appendages as long as the width of the gland, and 3–several round-dentate on the margin. In this species the fifth involucral gland is replaced by a small triangular-entire sixth lobe, the stems are striate, and the leaves denticulate all along the lower, and for one-half the upper margin. The seeds are pink, strongly tetragonal, narrowly elongate-pyriform, 1.5^{mm} long, 0.6–7^{mm} broad, and have all the facets concave and traversed transversely by numerous anastomosing rugæ.



In Dr. Palmer's 897 the leaves are larger and all parts except the involucres more robust than in his 225, in which nearly all the leaves are of the character of the minute floral leaves in the first.

EUPHORBIA STICTOSPORA Engelm. Mex. Bound. Bot. 187.

The triangular involucral lobes of this species are not "profunde fimbriatis" but densely hairy, the hairs being of the same size and structure as those of other parts of the plant. The fifth

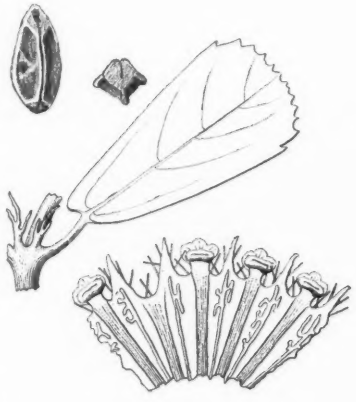


gland of the involucre is replaced by a triangular-linear sixth lobe. The involucre is more subcylindrical than turbinate. Seed ashen, somewhat falcate laterally, elongated-tetragonal, 1.4^{mm} long, 0.5^{mm} broad, the ventral facets concave, crossed by several prominent regular rugæ; the dorsal facets plane, densely covered by prominent irregularly anastomosing rugæ.

Dr. Palmer's 43 Durango specimens agree with the type, and are counterparts of Pringle's 80 Jimulco Valley, and 1076 plains of Chihuahua.

EUPHORBIA SERPYLLIFOLIA Pers. Ench. Bot. **2**:14.

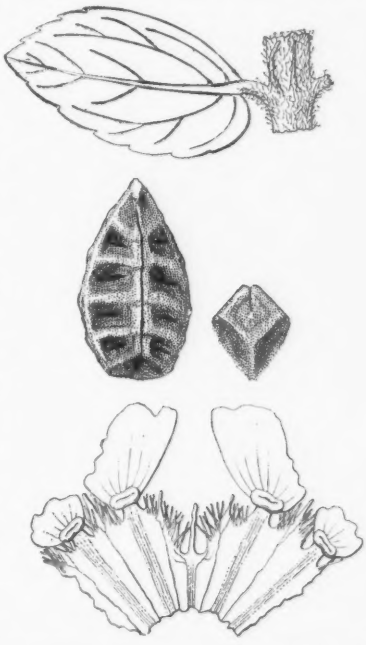
This species is readily distinguishable by its truncate-serrate leaves. The fifth gland of the involucre is represented by a truncate sulcus between two enlarged involucral lobes. Seeds ashen or amber-color, 1.1^{mm} long, 0.6^{mm} broad, strongly tetragonal; the facets of the ventral surface concave, marked by a few indistinct rugæ; those of the dorsal surface convex, rugæ anastomosing, and somewhat more evident.



In Dr. Palmer's 899 Durango the involucres are externally hairy, otherwise—though robust in habit—his specimens agree with the type, and with E. L. Greene's Bear creek (Colorado) and M. E. Jones' 3998 Flagstaff (Arizona).

EUPHORBIA ADENOPTERA Bertol. Misc. Bot. **3** : 436.

In this species a deep cleft replaces the fifth involucral gland which is also represented by a linear sixth lobe, otherwise the involucre is not "profunde fissis." The involucral lobes are more linear than "lanceolatis." The seed is pinkish-white, strongly tetrangular, 1^{mm} long, and 0.5^{mm} broad, all the facets plane and deeply scored by four or five transverse pits, the ridges separating which are projected to include the angles of the seed.



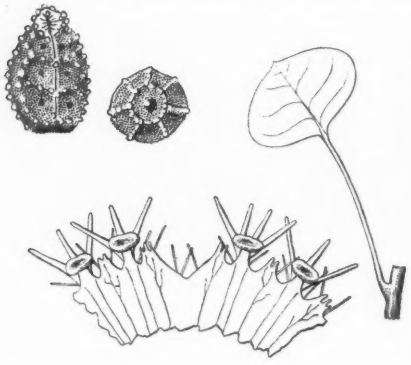
Dr. Palmer's 898 Durango agrees exactly with a part of J. G. Lemmon's Rucker valley and Churricahua mountains (Arizona) specimens. All these might be termed *forma rosea*, as the appendages and glands are so deep a red as to give the whole plant a roseate appearance. My Chichen Itza Yucatan 107 Allison V. Armour Exped. specimens are also of this form, but differ in having all the stem leaves narrowly lanceolate like the intrafloral leaves of the usual form. Dr. Arthur Schott's 966 Sisal, Yucatan, is apparently a transition from the last to the first form, while Dr. Gaumer's 938 Izamal is more markedly like the Durango form, his specimens being the largest I have seen; his 939 Sitilpech is, however, a very straggling open growth with long virgate branches.

§ CYTTAROSPERMUM.

EUPHORBIA SUBRENIFORME Watson, Proc. Am. Acad. **21** : 439.

In this species the fifth involucral gland is represented by a

deep triangular sinus flanked by unaltered lobes. Involucral lobes 2–4-irregular toothed (not entire, ciliate, as described). Walls of the involucre thin-membranous, columnæ wanting, external hairs few, setose. Seed ashen, globular-pyriform, 1.1^{mm} long, 0.8^{mm} broad, the facets marked by 3–4 shallow punctate pits deepened by tuberculate dividing ridges, the tubercles tipped with an amber-colored mucilaginous accretion.

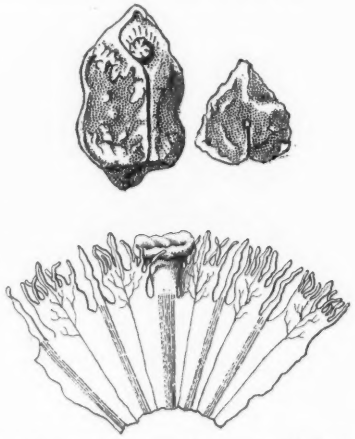


Dr. Palmer's 896 Durango agrees fully with C. G. Pringle's 2063 and 2302 Jalisco specimens.

§ Poinsettia.

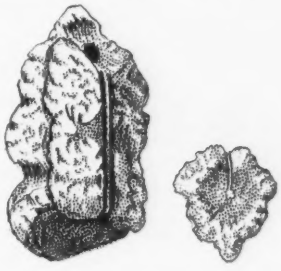
Euphorbia dentata lasiocarpa Boiss. DC. Prod. **15**: 72.

In this form and in the species as well, the involucral lobes are not dentate as described, but long-fimbriate. The four missing glands are replaced by an equal number of linear involucral lobes. Seeds dark reddish-brown, 2.4^{mm} long by 2^{mm} broad, sharply triangular in section, the facets, especially those of the dorsal surface, roughly white tuberculate.

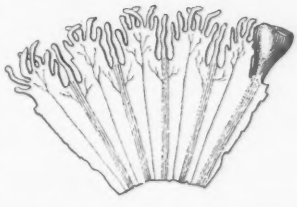


Dr. Palmer's 660 in part and 895 Durango specimens are the most usual form of this variety.

EUPHORBIA HETEROPHYLLA GRAMINIFOLIA (Michx.) Engelm. Mex. Bot. 190.

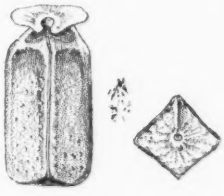


Dr. Palmer's 659 Durango is the typical form of this variety, the lower leaves being scabrous above, and strigose with long scattered hairs beneath. The four missing involucral glands are represented by a like number of linear lobes. The seeds, instead of being lenticular in section as in the species, are even more sharply triangular than in var. *eriocarpa* Millsp.

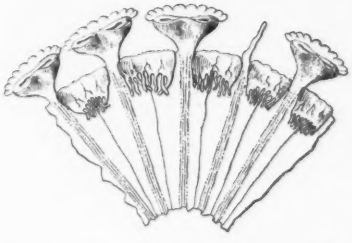


EUPHORBIA JALISCENSIS Rob. & Greenm. Proc. Am. Acad. **29**: 392.

Dr. Palmer, in his 660 (in part) Durango, rediscovers this interesting species, first collected in the barranca of Tequila by Pringle (4608) in 1893. His specimens agree with the type except that they are less robust in habit; notwithstanding this the leaves show still more clearly their sessile character.



In this species the leaves tend rather to be acute than obtuse; although apparently "winged petiolate," the dilation of the wings at the juncture with the stem, and their continuation above with the leaf, proves them sessile. The glands are stipulate, with appendages 8–12-crenate-dentate. The fifth involucral gland is represented by a linea blunt lobe. The involucral lobes are strongly



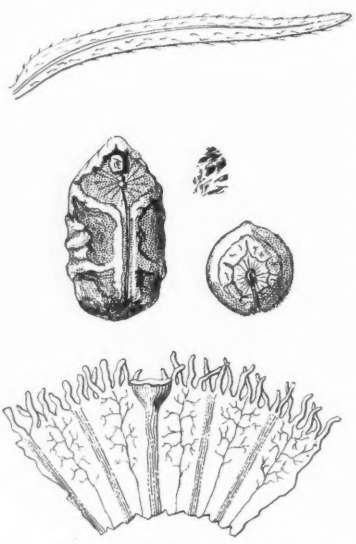
incurved. The striking columnar dark seeds are almost perfectly tetragonal, 4.5^{mm} long, and 2^{mm} broad, with the concave ventral facets slightly papillate; the caruncle is large, stipitate, and shaped like a water-carrier's neck yoke.

EUPHORBIA JALISCENSIS **Durangensis** var. nov.

This form differs from the species in its denser foliage and more ramose habit. Heterophyllous; lower leaves linear-lanceolate, 0.5 to 4 inches long, upper leaves spatulate to panduriform, dentate at the cuneate apex, 1–2 inches long, as broad above the constriction as below. Involucre smaller than in the species, the glands less stipitate, the appendages narrower and only 4–6-crenate-dentate, the seed blacker and smaller (3^{mm} long, 1.8^{mm} broad), and the caruncle simply peltate.

Collected by Dr. Edward Palmer in the vicinity of Durango, 1896 (658).

EUPHORBIA RADIANS Benth. Pl. Hartweg. 8.



The involucres of this species, described by Boissier (DC. Prod. **15**: 74) as subsessile, are pediceled one-half the length of the tube; the involucral lobes are from 4–6-fimbriate, the four missing glands are replaced by similar 1–2-fimbriate false lobes. The seeds are ashen, ovate, globular in section, 4.1^{mm} long, by 2.5^{mm} broad, the ventral facets marked by a strong transverse ridge, the dorsal by two, and numerous irregular verrucæ, not "smooth;" a smooth seeded species could hardly belong to POINSETTIA.

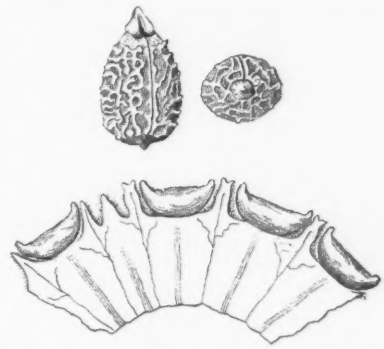
In Dr. Palmer's 34 Durango, the strigose hairy leaves are

very characteristic, and agree with J. G. Lemmon's Huachuca mountains and C. Mohr's Gila river (Arizona) forms.

§ TITHYMALUS.

EUPHORBIA CAMPESTRIS Cham. & Schl. Linn. **84**: 1830.

In this species the fifth gland is replaced by a triangular pointed lobe, broader at the base than the involucral lobes, which are in part triangular and part fusiform with a bifurcate apex. The seed is oval, lenticular in section, 2^{mm} long, 1.3^{mm} broad, dark brown, the surface reticulate with rounded anastomosing whitened-farinose ridges. Caruncle conical stipitate, deeply notched on the ventral surface.



Dr. Palmer's 72 Durango is the typical form of the species, with long virgate branches denuded below and terminated by numerous narrowly-lanceolate mucronate-tipped leaves, and a single 3–5 flowered umbel.

FIELD COLUMBIAN MUSEUM,
Chicago.

A GENERAL REVIEW OF THE PRINCIPAL RESULTS OF SWEDISH RESEARCH INTO GRAIN RUST.[1]

PROFESSOR DR. JAKOB ERIKSSON.

SINCE 1890 extensive researches into grain rust have been carried on at the Experiment Station of the Royal Swedish College of Agriculture. The results of these researches from the years 1890 to 1893 will be found in an extended official report,[2] and from the years 1894 to 1896 in a series of smaller papers in different journals.[3] The general review of the principal results of these investigations, which I am about to give, can best be set forth in some general theses that comprehend the sum of the results obtained.

[1] Lecture before the second Scandinavian Congress of Agriculture at Stockholm, July 20, 1897.

[2] J. ERIKSSON and E. HENNING.—Die Getreideroste, ihre Geschichte und Natur. so wie Massregeln gegen dieselben. Stockholm: P. A. Norstedt & Sön, 1896, 8vo (2; VII+463+1).

[3] J. ERIKSSON, Über die Specialisierung des Parasitismus bei den Getreiderostpilzen (Ber. d. deutsch. bot. Ges., 1894, 292–331); Über die Förderung der Pilzsporenkeimung durch Kälte (Centralbl. f. Bakter. u. Paras.-Kunde, 1895, Abt. 2, 557–565); Ist die verschiedene Widerstandsfähigkeit der Weizensorten gegen Rost konstant oder nicht? (Zeitschr. f. Pfl.-Krankh., 1895, 198–200); Welche Grasarten können die Berberitze mit Rost anstecken? (*Ib.*, 1896, 193–197); Welche Rostarten zerstören die australischen Weizenernten? (*Ib.*, 1896, 141–144); Neue Untersuchungen über die Specialisierung, Verbreitung und Herkunft des Schwarzrostes (Jahrb. f. wiss. Bot., 1896, 377–394); Studien über den Hexenbesenrost der Berberitze (Puccinia Arrhenateri Kleb.) (Cohn's Beitr. z. Biol. d. Pfl., 1897, 1–16); Vie latente et plasmatique de certaines Uredinées (Compt. rend., 1897, 475–477); Der heutige Stand der Getreiderostfrage (Ber. d. Deutsch. Bot. Ges., 1897, 183–194); Einige Bemerkungen über das Mycelium des Hexenbesenrostpilzes der Berberitze (*Ib.*, 1897, 228–231); Zur Charakteristik des Weizenbraunrostes (Centralbl. f. Bakt. u. Paras.-Kunde, 1897, Abt. 2, 245–251); Neue Beobachtungen über die Natur und das Vorkommen des Kronenrostes (*Ib.*, 291–308); Schutzmassregeln gegen die Berberitze (Zeitsch. f. Pfl.-Krankh., 1897, 65); Über den Berberitzenstrauch als Träger und Verbreiter von Getreiderost (Die landw. Vers.-Stat., 1897, 83–95) und Weitere Beobachtungen über die Specialisierung des Getreideschwarzrostes (Zeitsch. f. Pfl.-Krankh., 1897, 198–202).

1. *The kinds of fungus which produce rust in cereals are at least ten in number (partly species, partly specialized forms of species), and the spread of the disease from one kind of cereal or grass to another is thereby considerably restricted.*

In order to illustrate the situation of the grain rusts in this regard, I would call attention to the accompanying table, in which can be seen what the former situation was, that is to say, in 1890 when this investigation began, and what it is now in the summer of 1897.

At the first glance this table shows how different the position is now from what it was formerly. Then we supposed that three species of rust were found on our cereals; one of them called *Puccinia graminis* occurred on all the four cereals, another *P. rubigo-vera* (*P. straminis*) on rye and wheat, and a third *P. coronata* on oats, to which finally a fourth form, *P. simplex* on barley, was added, ordinarily considered to be only a variety of *P. rubigo-vera*. We also thought that all the kinds of Gramineæ that bore a certain species of rust (*P. graminis* is observed on a hundred species of Gramineæ in Sweden) were able to infect one another.

How different our apprehension must now be! It appears that if we stop with the four cereals we have to count in Sweden not less than ten different forms of rust, and I have cause to suspect that on the continent of Europe one or two other forms are to be found. These ten forms are distributed among at least five species in such a way that there occurs

(1) One form of black rust on rye and barley,
(2) One form of black rust on oats,
(3) One form of black rust on wheat,
(4) One form of yellow rust on wheat,
(5) One form of yellow rust on barley,
(6) One form of yellow rust on rye,
(7) One form of brown rust on rye,
(8) One form of brown rust on wheat,
(9) One form of dwarf rust on barley, and
(10) One form of crown rust on oats.

SYSTEMATIC TABLE OF THE FORMS OF THE GRAIN RUST FUNGUS, PUCCINIA.

Formerly: (1880): Species Variety.	1 GRAMINIS Pers. (Aecidium Berberidis)		2 RUBIGO-VERA DC. (Aec. asperifolii) SIMPLEX Kcke.			3 CORONATA Corda (Aec. Rhamni)		
Now (1897): Species:	1 GRAMINIS Pers.4 Black rust (Aec. Berberidis)	2 PHLEI-PRATENSIS Er. & Hen. Timothy rust (Aec. –)	3 GLUMARUM (Schw) Er. & Hen. Yellow rust (Aec. –)	4 DISPERSA Er. & Hen. Brown rust (Aec. Anchusae)	5 SIMPLEX (Kcke.) Er. & Hen. Dwarf rust (Aec. –)	6 CORONIFERA Kleb. Crown rust (Aec. catharticae)	7 CORONATA (Corda) Kleb. (Aec. Frangulae)	8
Specialized forms:	1 SECALIS on *Secale cereale* " *Hordeum vulgare* " " *jubatum* " *Triticum repens* " " *caninum* " " *desertorum* " *Elymus arenarius* " *Bromus secalinus* 2 AVENAE on *Avena sativa* " " *elatior* " " *sterilis* " *Dactylis glomerata* " *Alopecurus pratensis* " *Milium effusum* " *Lamarckia aurea* " *Trisetum distichophyllum* 3 TRITICI on *Triticum vulgare* 4 AIRAE on *Aira caespitosa* 5 AGROSTIDIS on *Agrostis canina* " " *stolonifera* " " *vulgaris* 6 POAE on *Poa compressa* " " *caesia*	on *Phleum pratense* " *Festuca elatior*	1 TRITICI on *Triticum vulgare* 2 SECALIS on *Secale cereale* 3 HORDEI on *Hordeum vulgare* 4 ELYMI on *Elymus arenarius* 5 AGROPYRI on *Triticum repens*	1 SECALIS on *Secale cereale* 2 TRITICI on *Triticum vulgare* 3 AGROPYRI on *Triticum repens* 4 BROMI on *Bromus arvensis* " *Bromus brizaeformis*	on *Hordeum vulgare*	1 AVENAE on *Avena sativa* 2 ALOPECURI on *Alopecurus pratensis* " *Alopecurus nigricans* 3 FESTUCAE on *Festuca elatior* 4 LOLII on *Lolium perenne* 5 GLYCERIAE on *Glyceria aquatica* 6 HOLCI on *Holcus lanatus* " *Holcus mollis*	1 CALAMAGROSTIS on *Calamagrostis arundinacea* " *Calamagrostis lanceolata* 2 PHALARIDIS on *Phalaris arundinacea* 3 AGROSTIS on *Agrostis vulgaris* " *Agrostis stolonifera* 4 AGROPYRI on *Triticum repens* 5 HOLCI on *Holcus lanatus* " *Holcus mollis*	1 EPIGAEI on *Calamagrostis epigeios* 2 MELICÆ on *Melica nutans*

Between certain of these forms, that is to say, those which constitute a species (for instance the three forms of black rust) we have not succeeded in discovering, even with the aid of a microscope, any distinguishing difference in the outer appearance, such as the size, color, and distribution of the pustules, the shape and size of the spores, etc. However, there is a difference between them with regard to their inner nature that is of no little practical interest. The difference appears in that every form is almost exclusively confined to its particular cereal, and that consequently it is able to infect no cereal but that one. Thus stems of oats bearing black rust can propagate black rust to oats, but not to rye, wheat, or barley; stems of rye bearing crown rust can propagate crown rust to rye, but not to wheat, and so on. Plants of rye and barley attacked by black rust make an exception to this rule, as they are able to infect one another; in some cases also those of wheat propagate black rust to other cereals.

If we consider the thirty-seven kinds of grasses mentioned in the table, we observe that the forms of rust upon them distinguished at the present time reach the number of thirty, and that these forms are brought together under seven species.

The old *P. graminis* has been divided into two species, that is to say, *P. graminis* (black rust) with æcidium, and *P. Phlei-pratensis* (timothy rust) without æcidium; *P. rubigo-vera*, its form *simplex* included, has been divided into three species, *P. glumarum* (yellow rust), *P. dispersa* (brown rust), and *P. simplex* (dwarf rust); and finally *P. coronata* into two species, *P. coronifera* (crown rust) with æcidium on *Rhamnus cathartica*, and *P. coronata* with æcidium on *R. Frangula*. Two forms, the last two in the table, are for the present arranged separately because we have

[4] In this column are yet to be arranged the forms of black rust on the following nine grasses: *Aira flexuosa*, *Alopecurus nigricans*, *Elymus glaucifolius*, *Panicum miliaceum*, *Phleum Boehmeri*, *P. Michelii*, *Poa chaixii*, *P. pratensis*, and *Triticum unicum*, with regard to their capacity for passing to a barberry. So far it has not been possible, on account of lack of æcidiospores, to range each of these forms in its proper place in the species.

not yet been able to effect any tests by which their true place can be defined.

We can easily see that the consequence of this abundance of forms ought to be a very considerable reduction in the capacity of the rust to propagate itself from one species of grass to another. To be sure rye and barley are able to infect one another with black rust, as illustrated in the table, and they also can be infected by *Triticum repens*, *T. caninum*, and several other grasses. In the same manner oats may be infected with black rust from *Dactylis glomerata*, *Alopecurus pratensis*, and several other grasses. For all the other eight forms of rust occurring on our cereals, however, as well as for the forms of rust on the wild grasses and the fodder grasses generally, it has not been possible to discover any source of the disease among surrounding grasses of other species.

But some one may ask if the proofs brought forward for the difference between the forms—proofs which have been gathered from experiments with the fungi in their uredo stage, as they occur on culms and leaves of grasses—are completely satisfactory. If it is a fact, as seems to follow from the table, that all forms of black rust are like each other in that they are able to alternate on barberry, producing an æcidium upon it, of course the query presents itself whether this bush is not able to serve as a connecting bridge between the forms which show their distinguishing features in the uredo stage; whether, indeed, an æcidium that, for instance, arises from the black rust on oats may not be able to produce an outbreak of black rust not only on oats, but also on the other cereals, nay, on every grass that is susceptible to black rust. Many trials made during the last six years have proved conclusively, however, that it is not so. An æcidium arising from black rust on oats is able to infect, among the cereals, only oats, while an æcidium arising from black rust on rye or barley can produce rust only on rye or barley, and so on. The different forms of black rust are thus entirely separated one from another in all their stages—as uredo and puccinia on the grasses and as æcidium on barberry

—and the small propagation of black rust by external infection, mentioned above, is not at all affected by the intervention of the barberry.

2. *The propagation of rust is often slight* (a) *between species of Gramineæ capable of bearing the same specialized form,* (b) *to and from the æcidium host* (*where there is one*), *and sometimes* (c) *between different cultivated varieties of the same cereal.*

By reference to the table we observe that the form of black rust first mentioned, called *f. sp. secalis,* may occur on rye and barley, as well as on *Triticum repens,* and several other grasses. In middle and southern Sweden *T. repens* is more often and abundantly attacked by black rust than any other grass. It would be natural to suppose that if the several Gramineæ named grew in the vicinity of one another and one should be attacked the infection would ordinarly spread to the others. If so, rye and barley ought to be frequently attacked by black rust. Such, however, is not the case. Barley is comparatively little affected by this form of rust, and rye does not suffer from it to any great degree.

It has been observed, furthermore, that barley growing near *Triticum repens* covered with black rust has remained clean week after week, although the weather had been very favorable for the propagation of the disease. We may incidentally allude to other observations in which the propagation of the disease from rusted stalks to the æcidium host, or contrarily from this plant to susceptible Gramineæ has been much less than we expected.

But, also, propagation of rust has very often appeared to be small between different cultivated forms of the same kind of cereal, and even between different individuals of the same grass. There is, indeed, scarcely an agriculturist who has not sometimes observed that different varieties of wheat are very differently attacked by yellow rust. One variety may be almost clean, while another is entirely destroyed. Such a case which was particularly noted may be here related. In the summer of 1894 a variety of winter wheat (Horsford's pearl wheat), very susceptible to yellow rust, was cultivated at the Experiment Station

in a small plat. Round this plat five other varieties of wheat were sown, also in small plats, all these varieties being well known for several years as very little susceptible to yellow rust. On May 11 the middle plat showed traces of yellow rust. After thirty-three days the rust had increased a little, and after ten days more the rust had reached its maximum, the greatest degree of destruction. But at the same time all the surrounding plats at the end of the thirty-three days were clean, and at the end of the following ten days two plats still continued quite clean, and the other three only showed small traces of rust. All the plats were sown on the same day, and the weather during the last part of May and the beginning of June was part of the time very rainy.

Here we have an example of what is usually called the different susceptibility of varieties to disease. Such a different predisposition for yellow rust we have up to this time been able to point out with certainty in different varieties of wheat and barley. In view of observations made during the summer of 1896, I have reason also to suspect such a predisposition in the different varieties of wheat for brown rust, a kind of rust, however, that has but subordinate practical interest in Sweden.

Sometimes we find only a slight propagation of rust, even between different individuals of the same wild grass. I have observed specimens of *Festuca elatior* badly attacked by *Puccinia coronifera* alternating with healthy ones, or specimens of *Poa pratensis* destroyed by *P. Poarum* alternating with healthy ones, or specimens of *Brachypodium silvaticum* attacked by *P. Baryi* among completely healthy ones.

3. *The germinating power of the uredo- and æcidiospores is often small, or at best capricious.*

The fact that the yellow rust in wheat shows so little transmission from one variety of wheat to another has led to making the germination of summer spores (uredo- and æcidiospores) the subject of special investigation. It appears that in certain kinds of rust these spores are uniformly very capricious in their germination, and even sometimes absolutely refuse to germinate,

even if they lie in water for four or five days. Such is the case for instance with the uredospores of yellow rust (*Uredo glumarum*), with æcidiospores of black rust (*Æcidium Berberidis*), and so on.

The cause of this remarkable state of things has been a matter of much perplexity, and many experiments were set on foot in order to learn a way of increasing the germinating power, at least to some extent. Such a way was finally discovered, which was to cool them. Ever since the old Roman days cultivators have observed that alternating cool nights and warm days favor the development of rust. From this the thought came to me to cool the spores by putting them on ice, or by chilling them in water for several hours. How strange it is, indeed, that these experiments should often give positive results! The dormant power of germination is brought to life, and with certain kinds of spores only in this manner has it been possible to carry out infection experiments. This capricious germination partly accounts for the small propagation of the disease already mentioned. But this alone does not give complete explanation, for such a restricted propagation is also to be observed in forms whose spores as a rule germinate very well. The whole cause must, therefore, be sought elsewhere.

4. *The spread of rust depends to an important degree upon the distances.*

For the purpose of explaining the outbreak and spread of rust in grain fields we have not generally been concerned with the distances separating the fields from a suggested source of infection. The pustules of rust once appearing on the barberry, the primary source of the whole neighborhood's infection was thought to have been found. It was believed that at first the nearest fields became rusted, through them in eight days afterwards the somewhat remote region, and so on. The farther from the original source, the more secure one could be. Sometimes, however, this protective distance must apparently be considerable. Black rust has been observed in the Indian wheat fields with no barberry as the source of infection nearer than 300 miles, on the Himalayas. However, we sometimes find recorded a different opinion. Thus,

one of the most respected authorities in this subject, Professor Julius Kühn, of Halle, proclaimed the opinion in an official report of 1875 that a distance of 100 meters between the barberry bush and the grain field may be considered sufficiently protective.

During the last few years many experiments have been set on foot at the Experiment Station, and many observations made in the open field, in order to gain some knowledge regarding this important question, and all these experiments and observations point to the same conclusion. They show that the matter of distance is of the greatest importance, as well in the spread of the disease in spring from rusted Gramineæ to barberry, etc., as in a like spread in summer from barberry, etc., to the Gramineæ, and finally from one of the Gramineæ to another. This has been found true not only for a single year, but for all the years, at least five, that I have had my attention turned to the subject. By observation on the rust's appearance upon *Triticum repens* at different distances from a barberry bush it has been proved beyond doubt that the influence of the bush does not extend farther than 10 to 25 meters.

For these reasons it was insisted upon in the circular, which a short time since was sent out to several of the officials in Sweden, that no barberry, wild or cultivated, be permitted to grow at a distance less than 25 to 50 meters from a grain field.

5. *The germinating power of the winter spores (teleutospores) depends upon certain external conditions, and is restricted to a short period of time.*

The winter spores of black rust are capable of germination in spring only in case they have been exposed to quite natural conditions of cold, snow and rain, during the previous winter; and consequently rusted litter preserved in a barn or in a stack is not to be regarded as dangerous. This has been fully demonstrated in the results of the first four years as given in the detailed report.

Observations and experiments made during the current year have brought to light still another matter of interest concerning the germinating power of the spores. It appears that only the

crop of spores maturing during late autumn is able to germinate the following spring.[5]

All that I have now set forth—(1) the multiplicity of fungous forms producing the rust disease, (2) the obstinacy of some uredo- and æcidiospores in germination, (3) the great importance of the matter of distance, and (4) the conditional and short-lived germinating power of the teleutospores—cannot well be brought into agreement with the view which has been held, and is yet generally prevalent, with regard to the outbreak and propagation of grain rust, and we may perhaps say of parasitic plant diseases in general, viz., that it is the continual accession of new infective material and the continual formation of new centers of infection which cause the outbreak and the intensity of the disease. The five theses set forth above give each in its degree a hard wrench to the corner stone upon which the whole doctrine of grain rust has been resting for a long time.

It may be asked whether this overthrow of prevailing opinions is the only or principal result of the investigations. Does it not present some more positive result, some new starting-point upon which a new doctrine may be founded, and from which new work may begin? I am obliged to be brief at this time, and to give merely a short and summary review of my results, referring for details to the special works already published or soon to be published.

I shall first call attention to two observations that were easily made, but no less remarkable for that reason. Each of them gave cause to suspect a source of rust quite different from that which we have been accustomed to look for.

6. *The yellow rust appears in certain varieties of wheat and barley that are especially susceptible, uniformly four to five weeks after sowing.*

7. *The intensity has sometimes been stronger in sunny than in shady places in the same wheat field.*

These two observations, together with the results from sev-

[5] Details will soon be published elsewhere.

eral special investigations upon the succession of the rust pustules, etc., related in the work "Die Getreideroste," could not fail to excite suspicion that perhaps the source of disease is an internal one, included within the plant itself.

How then test whether this suspicion might be right or not? The first experiments made with this in view showed that

8. *Wheat plants, which early in the spring, immediately after the melting of the snow, were enclosed in long and large glass tubes stuffed with cotton wool above and below, and consequently carefully protected against external infection, developed stalks that after six to eight weeks showed yellow rust.*

There is no possibility of explaining this outbreak of rust through external infection taking place immediately before or after enclosing in the tubes. The immediate sources of the disease in these cases must have been an internal one. Here two possibilities seem to suggest themselves. The first is that in late autumn of the previous year, during early growth of the wheat, an external infection came from teleutospores or uredospores of the yellow rust, germinating upon the seedlings; and that the fungus afterwards lived a hidden internal life until the full outbreak in the spring. The other possibility is that germs of disease had been inherited by the seed grain from the parent plant itself.

In order to decide between these two possibilities it has been necessary to arrange the experiments in a special way. Therefore I have sowed grain in sterilized soil and protected the growing plants from external infections by raising them in glass houses constructed so that the air could pass in only through cotton-wool filters. Such experiments in glass houses of different construction have been carried on for four years, and have shown that

9. *Plants of a variety of barley extremely susceptible to yellow rust, grown in sterilized soil and protected from external infection in isolated glass houses, have sometimes become rusted.*

These results prove beyond doubt that the disease must come from internal germs inherited from the parent plant.

But in what form are these internal germs of disease living? Is it easy to follow and identify them with the microscope? Not at all. They can only be detected just before the breaking out of the young pustules. The microscope examination induces me to suppose that

10. *The fungus lives for a long time a latent symbiotic life as a mycoplasma in the cells of the embryo and of the resulting plant, and that only a short time before the eruption of the pustules, when outer conditions are favorable, it develops into a visible state, assuming the form of a mycelium.*

To speak comprehensively, the investigation above outlined gives the following general conclusions:

A. The outbreak of grain rust is due (a) *in the first place to germs of disease in the host plant itself, which in certain cases are inherited from the parent plant through the seed, and in which they lead a latent symbiotic life as a mycoplasma and continue to do so afterwards for a long time in the resulting plant, and* (b) *in the second place to external infection from the vicinity.*

B. The intensity of grain rust is due (a) *in the first place to the degree with which the dominant outer circumstances* (*weather, soil, manuring, and so forth*) *are able to convert the inner germs of disease from the latent stage of a mycoplasma into a visible stage of mycelium, and* (b) *in the second place to the accession of infective material from without.*

So far have we now gone in our knowledge of the nature of grain rust. Many things that before seemed incomprehensible have now a natural explanation, and our point of view has been very much changed. Especially have the experiments so far carried out provided a new method for explaining the varying susceptibility of different varieties of cereals, and have thus given a new point of departure for continued efforts for the mastery of the disease in the open field. We are warranted in suggesting that the predisposition of the Hosford wheat to yellow rust may be explained by assuming that between this variety of wheat and the yellow rust an extremely vital mycoplasma-symbiosis is to be found, while on the contrary the Squarehead

wheat is nearly exempt from the rust for the reason that no such symbiosis has arisen between this wheat and the fungus.

With this fundamental view as a point of departure we have yet to ascertain to what degree we can by different manures, by different treatment of the soil, by different time of sowing, etc., influence the internal germs of disease in such a manner that the transformation from the latent mycoplasma stage to the sporiferous mycelium stage may be as much as possible delayed and prevented. We have further to make use of the knowledge gained in the selection and cultivation of varieties as little susceptible to the disease as possible. We have to find out to what degree by crossing we can combine a small susceptibility to rust with a strong resistance to cold, and finally whether certain regions may not tend to repress the development of the inner germ of the disease, and thus become regions for the production of certain kinds of cereals.

The questions above mentioned are of great practical importance, and they suggest a very rich field for further investigations

STOCKHOLM, SWEDEN.

RED YEASTS.

KATHERINE E. GOLDEN and CARLETON G. FERRIS.

(WITH PLATES II AND III)

THE so-called red yeasts are what are known as "wild" yeasts, and occur usually in the air. Though several species of these yeasts are known, but two, *S. rosaceus* and *S. glutinis*, are described and named. *S. rosaceus* has been studied by Hansen, but as no spores were formed during its development, he excluded it from the true Saccharomycetes. The same exclusion should apply to *S. glutinis*, for in this species, also, spore formation is unknown. In an article of recent publication, Swan[1] describes a red yeast obtained from a stale egg, which formed spores, although under somewhat extraordinary circumstances. Instead of forming spores on the gypsum block or on filter paper in the ordinary way and at 25° C. or 15° C., Swan obtained the spores in growths on wort gelatine, in the light, and at a temperature between 5°–10° C., the first indications of spores appearing in ten to fourteen days. He does not state whether or not he used ordinary conditions before resorting to these somewhat peculiar ones. The article is accompanied by photographs which show unmistakable spore formation in the yeast cells.

Of three red yeasts which the writers obtained from the air of the laboratory, and designated numbers 1, 2, 3, number 1 was at first supposed to be the same form that Swan had examined, but with subsequent work it proved to be different, varying in certain characteristics, notably the manner of growth of the colonies and the spore formation. The colonies show considerable growth in three days, and are of a dull pink color. They are not raised from the surface of the gelatine as were those of Swan, but are round and flat and have smooth edges (*Plate II*,

[1] Central. f. Bakt. u. Parasitenk. **2**: 1–11. 1896.

A). As the colonies age their color becomes much deeper, until in old growths the color is a vivid red. The color is not affected by the ordinary acids or alkalies. The cells show no color under the microscope, are oval or round, the average size being 8.6 $\mu \times 6.4\ \mu$. During vigorous growth the cells have from one to three vacuoles, the protoplasm shows very little granulation, and no chain formation takes place. The cells form but one bud at a time, and the bud separates from the mother cell before a second bud is formed. The following table gives the characteristics of growth under various conditions:

NUMBER 1.

No.	Kind	Medium	Temp.	Color	Manner of growth	Age days
		10%				
1	Streak	Wort-gelatine	21° C.	Red	Abundant, oily in appearance, smooth edges	21
2	"	"	7° C.	Pale pink	Slight growth, oily, smooth edges	21
3	"	"	17° C.	Red	Same as no. 1	21
4	Stab	"	21° C.	Red	Growth on surface only, oily, smooth edges	21
5	"	"	7° C.	Pale pink	Slight growth, other respects like no. 4	21
6	"	Agar	21° C.	Deep red	Growth very heavy	21
7	"	Starch paste	21° C.	Pale pink	Slight growth on surface.	14
8		Wort	21° C.	Pink	Heavy sediment, liquid turbid, no gas, ring at surface	4
9		Bouillon	21° C.	Pale pink	Slight sediment, liquid cl'r, thin granular film	4
		5%				
10		Dextrose	21° C.	Red	Heavy sediment, liquid cl'r, no gas	18
11		"	7° C.	Faint pink	Slight growth	47
12		Glucose	21° C.	Pink	Like no. 10, but less sediment	18
13		"	7° C.	Faint pink	Slight growth	47
14		Sucrose	21° C.	Red	Most abundant growth of sugar solutions, liquid slightly turbid, thin film, heavy ring at surface	18
15		Dist. water	21° C.	Very faint pink	Slight sediment, cells empty	11
16		Lactose	21° C.	Pink	Next to 14 in growth, film	18
17	Ferm. tube	Pasteur sol. with sugar	21° C.	Pink	Sediment in bend of tube, no gas	30

The foregoing table gives a general idea of the conditions used for the growth of number 1. It was found that the yeast

in a stab culture in gelatine or agar gave no growth along the needle track, the color being entirely at the surface, this showing it to be aerobic. Upon 10 per cent. wort gelatine and nutrient agar the best growths were obtained, and in the light. Various temperatures were tested, that between 17°–21° C. being found the best. At one time twenty-four varieties of yeast were grown at that temperature, and of the twenty-four number 1 gave the most vigorous growth. The color shows sooner and is stronger when the growth is made in the light. Inoculations in beer wort give a very appreciable growth in two days, the liquid becoming turbid, and a sediment forming. No film is formed, but in about a week a thin ring appears around the surface of the liquid; this ring increases in size and deepens in color with the age of the culture. Fair growths, as indicated by the sediment, were obtained in bouillon and in distilled water; in the latter, however, little color was present. Cultures in sugar solutions— sucrose, dextrose, maltose, lactose, and Pasteur solution with sugar— were made, and all of them offer good media for growth, though varying considerably. Remarkably large growths were obtained in lactose and sucrose, these being characterized by heavy sediment of a deep red color, heavy surface ring, and turbid liquid. A peculiar phase of the growth in sucrose is that the cells formed spore-like bodies. In no other of the sugars did this occur. Cultures in the sugars and in wort were made in fermentation tubes, but no gas was formed, though the cultures were kept for two months.

Spore formation was tested in the usual way, vigorously growing cells being placed on gypsum blocks. The blocks were kept under various conditions of light and temperature, with the result that at from 17°–21° C., and in the dark, granulations appeared in cells, these afterward forming spore-like bodies. The granulations first appeared in about forty hours, though it was about four days before the spore-like bodies were formed. These bodies are round and highly refractive, averaging 3.3μ in size, but developed no spore wall that could be distinguished. Being doubtful as to the true nature of these bodies, and think-

ing that probably they might be fat globules, the cells were treated with ether, alcohol, osmic acid, potash, and alkanet, all of which failed to change the bodies. Some of the cells were then placed in a drop of wort in a moist chamber at 25° C. to determine their method of germination. The chamber was placed under the microscope, so that any changes might be observed. In sixteen hours the bodies had become swollen, and they passed gradually from the swollen condition to the ordinary condition of the protoplasm in a vegetative cell. The spore-like bodies formed in the sediment and film of a 5 per cent. sucrose solution were tested in the same way, with like results. The conclusion which can be drawn from the behavior of this organism is that it is not a true yeast, but that the cells have the power of forming bodies which function as spores in preserving the organism from extinction under adverse conditions.

Plate III, B, shows the cells from a gypsum block with the contained bodies. Growths on blocks kept in the dark and at 7° C. developed but slight color, while blocks kept at 21° C. developed quite a marked color, both in the dark and in the light, thus indicating that a certain amount of heat is necessary for color development.

NUMBER 2.

No.	Kind	Medium	Temp.	Color	Manner of growth	Age days
1	Streak	Wort-gelatine	21° C.	Salmon pink	Oily, smooth edges, abundant	20
2	"	Agar	"	"	Oily, smooth edges, more abundant than in no. 1	20
3	Stab	Wort-gelatine	"	"	Slight growth along needle track	20
4	"	Agar	"	"	Slight growth along needle track	20
5	"	Starch	"	"	Oily growth on surface	20
6	Ferm. tube	Pasteur sol. with sugar	"	Pink	Sediment in bed, no gas	30
7		Bouillon	"	Pale pink	Heavy sediment, liquid turbid	18
8		Dextrose	"	"	Heavy sedim't, liquid clear	20
9		Lactose	"	"	" " " "	20
10		Glucose	"	"	" " " "	20
11		Sucrose	"	"	" " " "	20

The colonies of no. 2 are somewhat indistinct in color until they are about ten days old, when they have a yellowish-red color. Their general appearance is very nearly the same as those of no. 1, but when magnified, differences show, as seen in *Pl. II, C*. The plate cultures of the three forms, from which the photographs were taken, were made at the same time and under similar conditions. The photographs were also taken at the same time. The cells of no. 2 are round, averaging $4 \times 4\mu$ in size, and bud frequently. In stab cultures a slight growth appears along the needle track. In streak cultures, as also in colonies and the top of stab cultures, the growth is very oily in appearance, and possesses little or no color at first, though this develops as the culture ages, until in very old ones the color is quite marked. As in no. 1, the color is unaffected by the ordinary acids and alkalies. In wort and sugar solutions the growth is fairly vigorous, though not so much so as in no. 1. No film is formed, nor is any gas developed. No spores or spore-like bodies are formed either on gypsum blocks or in any of the growths, the only change in the cells, when placed under conditions for spore formation, being a granulation of the protoplasm.

NUMBER 3.

No.	Kind	Medium	Temp.	Color	Manner of growth	Age days
1	Stab	Agar	21° C.	Faint pink	Slight growth along needle track, surface growth dry, granular, abundant	14
2	Stab	Gelatine	"	Pink	Like no. 1	14
3	Streak	Agar	"	Pink	Growth abundant, dry, floury, most of color in center in heaviest growth, edges almost white	20
4	Streak	Gelatine	"	Pink	Like no. 3	20
5	Stab	Starch	"	Faint pink	Slight growth on surface	14
6		Wort	"	Pink	Turbid after a week, granular film, sediment heavy, no gas	20
7		Lactose	"	Faint pink	Slight sediment, no film, no gas	14
8		Dextrose	"	"	" " " "	14
9		Glucose	"	"	" " " "	14
10		Sucrose	"	"	" " " "	14

In no. 3 the colonies are entirely distinct from those of nos. 1 and 2; they stand out from the gelatine as feathery masses with very irregular edges, and of a salmon pink color. *Pl. II, D* shows the peculiar appearance very well. At first sight the colonies look somewhat like a mold, but upon closer inspection they show no ramifying filaments. This peculiar appearance of the colonies is due to the form of the cells, and their remarkable method of growth. A few of the cells have the regular round or oval shape of the ordinary yeast cell, but the remainder have irregular, swollen, or filamentous forms, resembling the involution forms of bacteria. *Pl. III, E* is from a vigorous growth on gelatine. These forms, with about the same length of filament are constant for young growths on solid media, also for the first colonies obtained from exposure to the air. In old growths the form varies, the filaments becoming much longer, and more branched; this lengthening and branching also takes place in cells grown in liquid media. *Pl. III, F* is a photograph from an old growth. *Pl. III, G* is a photograph from a culture in wort. The cells, though branching in a manner which resembles a mold, never develop a mycelium. The cells vary in size from 1.5μ to 3.13μ for the short diameter, and 3μ to 29μ for the long diameter. A fairly vigorous growth is obtained at room temperature on agar and wort gelatine. On both of these the growth is dry and floury in appearance, of a light pink color, and in stab cultures most of the growth is on the surface, only a slight growth appearing along the needle track. In wort it takes four or five days usually before there is sufficient growth to make the liquid turbid; then a film, that is granular, appears on the surface. There is no fermentation in wort or in any of the sugar solutions. In starch paste there is a slight pinkish growth on the surface, but very slight, however, compared with the growth on gelatine and agar.

Of the three forms studied not one of them is a true Saccharomyces. They resemble the Saccharomycetes in their appearance, both microscopically, and in gross growth, but they are unable to form true ascospores. No. 1 appears to be

a form between the Saccharomycetes and the Torulae, in that it forms spore-like bodies under the ordinary conditions for spore formation, but these bodies are not true spores, as they neither form the spore wall, nor bud in germinating. It resembles *S. rosaceus*, as heretofore described — excluding Swan's description — in appearance of colonies, and in not forming chains, but differs from it in forming spore-like bodies, and in size; *S. rosaceus* is 9–10μ in diameter, a larger form than no. 1. No such form is described in any of the standard works upon the Saccharomycetes, which would indicate that it is a new species.

No. 2 is undoubtedly *S. glutinis*, in spite of the fact that it is not of the same size as the *S. glutinis* as described in some of the later works. No. 2 answers the description in every other particular. An error seems to have crept into the description of this species in regard to its size, the other characters being practically the same in all the descriptions. Cohn[2] in 1875 gives 4–5μ as the size, while Winter[3] in 1881 gives it as 5–11×4μ, Schröter,[4] in 1893, gives 5–6×4–5μ, and Saccardo,[5] in 1897, gives the same size as Winter, 5–11×4μ. Jelliffe[6] in a list of Saccharomycetes occurring in the air gives *S. glutinis* among the number, but as he gives no description of his forms, it is impossible to tell which description he followed. The following description,[7] which was written by Schröter indicates probably the source of the error: *S. glutinis* (Fres.) F. Cohn (Zellen kugelig, 4–5μ breit) und *S. Fresenii* Schröter (Zellen ellipsoidisch bis cylindrisch, bis 11μ lang, 4–5μ breit) schlagen sich häufig aus der Luft auf Leim nieder und bilden fleisch-bis rosenrote Schleimhäufchen.

No. 3 from its peculiar appearance would seem to be easy of identification. In general appearance it is very like *Mycoderma Humuli* as described by Lasché,[8] but it is unlike in that *M. Hum-*

[2] Beiträge zur Biologie der Pflanzen **1**: 187-8. 1875.
[3] Krytogamen-Flora von Deutschland **1**: 71. 1881.
[4] Krytogamen-Flora von Schlesien **3**: 207. 1893.
[5] Sylloge Fungorum **8**: 919. 1897. [6] Bull. Torr. Bot. Club **24**: 480-1. 1897.
[7] ENGLER and PRANTL, Pflanzenfamilien 1^1: 154. 1894.
[8] Zwei rothe Mycoderma-Arten, Der Braumeister **5**: 278-82. 1892.

uli liquefies the gelatine very quickly, sinking to the bottom as a red mass, forms a ring at the surface, and decomposes the liquefied gelatin, generating a foul odor, whereas no. 3 neither liquefies gelatin quickly nor gives off a foul odor in any stage of its culture. The indications are that no. 3 is a new species of Mycoderma.

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PURDUE UNIVERSITY, Lafayette, Ind.

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EXPLANATION OF PLATES II AND III.

PLATE II.

A. Colonies of no. 1 grown on 10% wort gelatine. ×100.

C. Colonies of no. 2 grown on 10% wort gelatine. ×100.

D. Colonies of no. 3 grown on 10% wort gelatine. ×100.

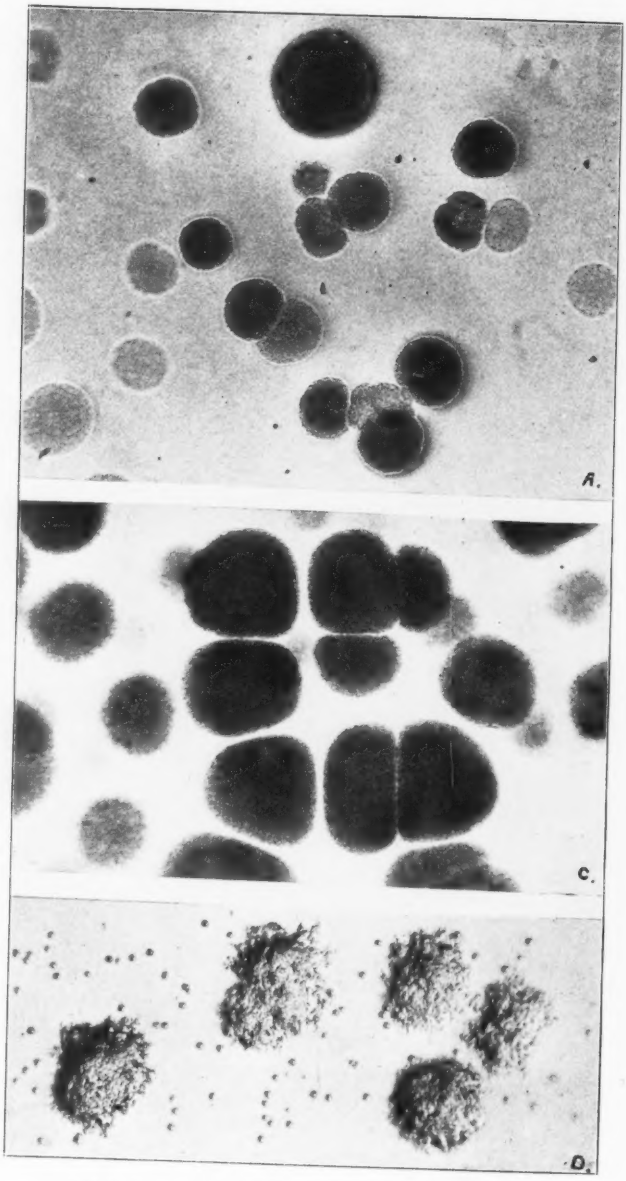
PLATE III.

B. Spore-like bodies, no. 1, grown on gypsum plates. ×495.

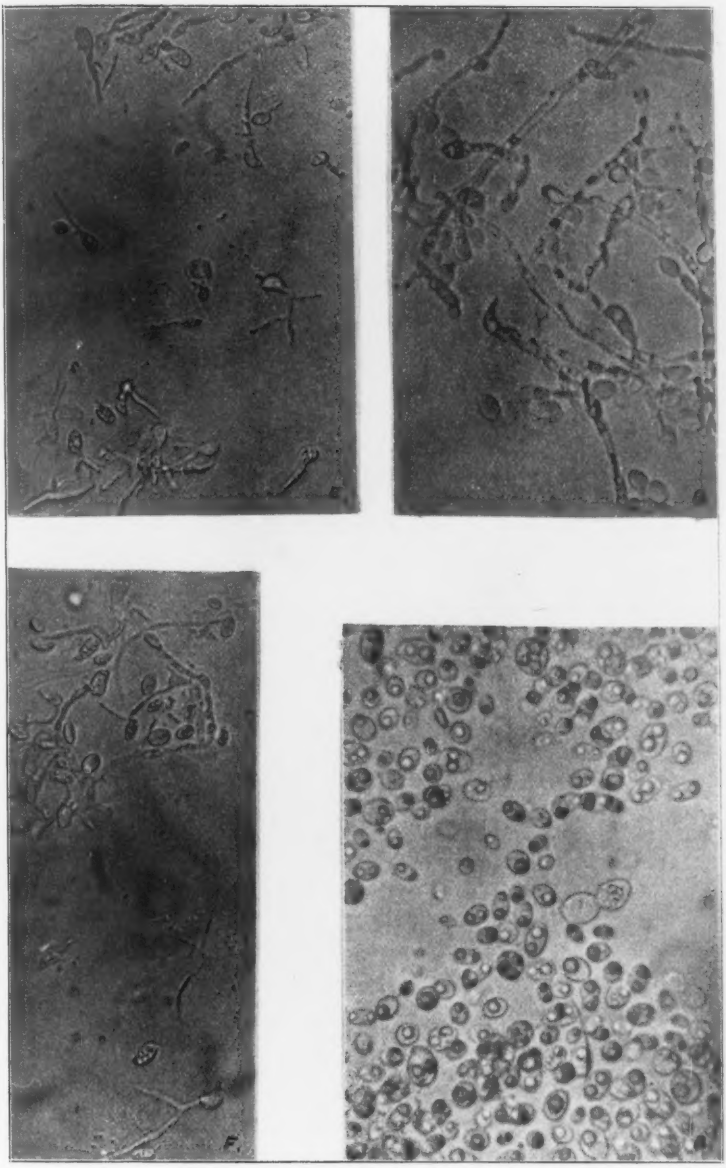
E. Cells of no. 3 grown on 10% wort gelatine. ×495.

F. Cells of no. 3 from old growth on agar. ×495.

G. Cells of no. 3 grown in wort. ×495.



GOLDEN and FERRIS on RED YEASTS.



GOLDEN and FERRIS on RED YEASTS.

BRIEFER ARTICLES.

CYNODON OR CAPRIOLA?

A BIBLIOGRAPHICAL STUDY.

WHILE engaged in a study of the Glumifloræ, as treated by the earliest botanical writers, we met not infrequently with the name "Capriola," which seemed to have been intended for some grass with digitate inflorescence. This name having been restored by Adanson as the earliest one for the genus now generally known as Cynodon, we felt induced to investigate the matter. Furthermore, Capriola has been revived by Dr. Otto Kuntze, and upon his authority it has been introduced into American systematic works of recent date, wherein the species appears as *Capriola Dactylon* Kuntze. It seems, however, as if the restoration of this name furnishes a good illustration of the difficulty sometimes confronting the naturalist who strives to determine what generic name ought to be adopted as the correct one for a certain plant, and since we have not been able to ascertain the true identity of the grass which formerly bore the name Capriola, we have thought that the present bibliographical sketch might be of some interest to American botanists. It is true that Adanson [1] restored the name, thinking it was identical with *Gramen dactylon* of the ancient writers, and his diagnosis, although very incomplete, does point toward Cynodon, which he thought was the plant which the ancient writers had in mind when they spoke of Capriola. Nevertheless, it is a very difficult matter to define Capriola as a definite genus, and at the bottom of the difficulty lies the fact that there are several other grasses with digitate inflorescence which were well known even to the earliest writers. It is quite natural that such grasses, unlike as they are to the majority of grasses, should attract attention at an early date, but it is also evident that the old botanists could not draw any clear distinction between the genera of such grasses, but simply referred to them as "finger-grasses." Some of these have later been recognized as *Panicum sanguinale*, Cynodon, Chloris, Dactyloctenium, Eleusine, Paspalum, etc.

[1] For references consult the bibliography appended to the article.

The fact is that Capriola was intended for *Panicum sanguinale* or for Cynodon, or perhaps for both together, but in no instance has this name been applied to any plant which can be identified with absolute certainty as the Bermuda grass, the genus Cynodon of Richard in Persoon's *Synopsis*. It is to be noted furthermore that Capriola is constantly preceded or followed by another name "Sanguinaria," sometimes written "Sanguinella," and it seems very significant that this last name is to be recognized as a modern popular one for *Panicum sanguinale*, viz., Paspale sanguin, Blutt-grasz, and Blut-hirse. But Capriola is not preserved in any form and gives no clue to its identification. It is derived from *caper*, not as a diminutive, but simply as indicating a plant liked by goats. The occurrence of Cynodon in sandy sections of the old world, where goats are kept in large numbers, may well speak for Cynodon as the grass it was made for, especially since *Panicum sanguinale* does not thrive well in sandy soil, but prefers the uncultivated grounds near dwellings, vineyards, etc. The popular name of Cynodon is, as we remember, Chien-dent, Hahnenbein, finger-grass, Bermuda-grass, etc.

We might add, in order to explain the singular popular name of our *Panicum sanguinale*, that this grass was once known to possess "bloody" properties. Thus both Dioscorides and Pliny have described a grass: "cui in cacumine caulinum quini sunt aculei veluti digiti," about which they state that when the spikes were pressed into the nostrils a bleeding was produced, and yet this same grass was used in dressing wounds to stop bleeding. This grass was generally known, therefore, as "Sanguinella" by the Etruscans, while others called it Capriola. It is interesting to notice that while the former use of Sanguinella has evidently been abandoned, the latter was recommended by Loeselius as late as the beginning of the eighteenth century. This author attributes this effect to his so-called Blutt-grasz, which according to his description must have been *Panicum sanguinale*. Whether Capriola, Sanguinaria, or Sanguinella were really intended as names for one single plant, it is unquestioned that the two latter have left a deeper trace in the history of economic plants than has Capriola. Such statements as are given by Dioscorides and Pliny concerning the medicinal properties of plants are of the greatest use in ascertaining the generic or specific name of some plant whose description is left too obscure. It seems, therefore, that by merely considering the name and properties of the plant in question, we might be justified in sup-

posing that *Panicum sanguinale* was the Sanguinella of the ancient writers. As regards Capriola, this name was generally used in connection with the former, as a local name for a plant, which at that time was considered identical with Sanguinella or Sanguinaria. However, there is a third name, "Dactylon," which was used by Pliny for a "finger-grass" possessing the same properties as Sanguinella, but there is no further clue to its identity. This plant "Dactylon" has evidently formed the basis for a number of finger-grasses by later writers, enumerated as *Gramen dactyloides*, etc., and it was one of these which Adanson considered as identical with Capriola. We see from these early data how very uncertain Capriola stands as a genus in botanical history, and we shall herein try to demonstrate that a consultation of the writers in the sixteenth and seventeenth centuries does not show any closer identity of Capriola with Cynodon.

Leonard Fuchs was perhaps the first writer who tried to identify Sanguinaria and Capriola, of which he makes mention in a chapter, "De Manna," in Brunfels' *Herbarum vivae eicones*. Both names are referred by Fuchs to the so-called "manna grass." Very few Gramineæ are described by Ruellius, but he knew Pliny's *Gramen aculeatum*, which he has discussed briefly. He mentions a new name for this grass, *Dens canis*, from which the later French name, "Chien dent" became derived; but he refers also to Capriola and Sanguinaria as synonyms. There is only one point in his very brief description of this grass which seems to throw some light upon its identity, and this is that the number of spikes is given as "quini senive." Cynodon is not known to produce more than four or five branches in the inflorescence, while it is very common to find seven in *Panicum sanguinale*. Although Lobelius has described a *Gramen Canarium* recognizable as Cynodon, and an *Ischæmon vulgare* which may be our Panicum, he does not give any reference to either Capriola or Sanguinaria. In accordance with Fuchs the "manna-grass" was adopted by Dodoens, who has not only described but even figured two species, *Gramen Mannæ primum* and *alterum*, both of which may readily be identified as *Panicum sanguinale* and *P. Crus-galli*. The figure of the first is so well executed that it makes any further comment unnecessary. We find here for the first time a true representation of *P. sanguinale*, and its geographical distribution was at that time given as Germany, Bohemia, Italy, and Belgium, where it was cultivated, but was found also naturalized in uncultivated fields, etc. One of its popular names

was at that time "Ros coeli" or "Himmel-dau," perhaps taken from its ability to retain the dew. This is the grass, Dodoens says, which Leonicenus and Ruellius have identified as the one formerly known as Capriola or Sanguinaria. Only three years after Dodoens we find Sanguinella and Capriola as synonyms for *Gramen Mannæ* in the writings of Camerarius, followed by the very important statement that this grass, whose figure bears great resemblance to *Panicum sanguinale* but not to Cynodon, was eaten by the Germans.

There exists no record heretofore that the grains of Cynodon have ever been gathered for eating, inasmuch as this grass yields but a relatively small number of mature seeds, a fact that is perhaps due to its extensive propagation by stolons. No mention is made in the elaborate works of Clusius of either Capriola or Sanguinaria. He merely describes *Gramen legitimum* and *Ischaemon*, in which our two plants seem to have been badly confounded. In accordance with Camerarius, Dalechamps describes "Grame de Manna," the figure of which is very characteristic, and shows us *Panicum sanguinale* without any question. He enumerates as synonyms Capriola and Sanguinella, and states that this plant is cultivated in south Europe. He has also described and figured Cynodon, which he calls "Dent de chien," but does not with one word allude to its possible identity with the former. This is perhaps the earliest record of a popular French name for Cynodon, which in later years became transcribed into "Chien-dent." The manna-grass has thus begun to be more generally adopted for our Panicum, and becomes also used in England, where Gerarde takes it up as his "*Gramen Manna esculentum*, the dew-grass," the last of which was evidently derived from Dodoens' "Ros coeli." A second species is Gerarde's "*Ischaemon vulgare*, the cock's-foot grasse," which is figured and seems to represent *Panicum glabrum*, while in his *Gramen dactyloides radice repente* we are able to recognize Cynodon. Following Gerarde, Parkinson has also adopted "cock's-foot grasse" for Panicum, whose Latin name he gives as *Ischaemon sylvestre*, while he calls Cynodon *Gramen Canarium Ischaemi paniculis*. A singular confusion as regards the name is to be observed in Johannes Bauhin's *Historia plantarum*, where *Panicum sanguinale* is figured, but named *Graminis genus Dens caninus*. Bauhin states in a small paragraph, however, that he does not believe that the identity of this grass with Capriola and Sanguinaria, as quoted from the ancient writers, can be ascertained without question. These grasses were distinguished, nevertheless, by

the younger Bauhin, who named them "*Gramen dactylon folio latiore*" (Panicum), and "*Gr. dactylon fol. arundinaceo*" (Cynodon).

By bringing all these statements together, drawn up from the various writers as far back as we have been able to trace our Panicum and Cynodon, it does not appear that Capriola was ever intended for Cynodon alone, but rather for *Panicum sanguinale*. The constant quotation of Capriola and Sanguinaria together seems to indicate that these were merely synonyms and popular names used in Italy. There are only two instances where we have found these names used for plants outside of the Gramineæ, but this is of little importance. Dodoens also used "Sanguinaria" for a plant which is readily recognized as *Polygonum aviculare;* and Tabernæmontanus in the beginning of the seventeenth century enumerated both Capriola and Sanguinaria as species of his genus Coronopus, which are easily identified as *Plantago Coronopus* and *maritima*. All the other writers have agreed that both Capriola and Sanguinaria are grasses, and Adanson is correct in applying Capriola to a grass. But this author does not seem to have had any reason for assigning the name *Gramen dactylon*, this name being yet too obscure.

If in spite of its uncertainty Adanson's name Capriola is to stand for the mere sake of priority, the question remains whether it is really identical with Cynodon or with *Panicum sanguinale*. The diagnosis given by Adanson for Capriola is not so characteristic that one can recognize in this the genus Cynodon of Richard. "Couronne de la gaîne des feuilles: poils; fleurs: épis digités; calice: plat par les côtés; corolle; sans arête," are characters that may just as well fit *Panicum sanguinale*. We have examined numerous specimens of this last and noticed that the ligule is often wanting and replaced by a small tuft of hairs, while the same organ in Cynodon is sometimes developed as a crescent shaped membrane. Furthermore, the empty glumes are also laterally compressed in *Panicum sanguinale*, and no awn is developed. Indeed, it seems as if Capriola has become more obscure through having been restored by Adanson than it was before. The adopting of Capriola must consequently result in confusion, which would easily be avoided by preserving Richard's well defined genus Cynodon, which no botanist could ever mistake for *Panicum sanguinale*. The fact that *Gramen dactylon* is a very obscure name, that Capriola of the old writers has been used for Panicum or for this and Cynodon together, and that Adanson's restored genus is not so certain, does not

encourage us to adopt Capriola for the mere sake of priority or for any other reason. It seems to be much more practical to use Richard's name, which is not antedated by any similar name, and which is well known to all botanists.—THEO. HOLM, *Washington, D. C.*

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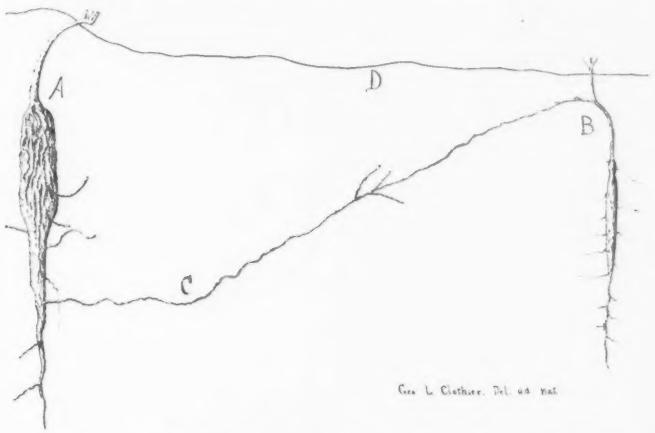
ROOT PROPAGATION OF IPOMŒA LEPTOPHYLLA.

A FEW notes upon the root propagation of *Ipomœa leptophylla* Torr. may be of interest, as the facts herein presented are believed to be unpublished.

As is well known, this plant, whose habitat is the dry sandy regions of the plains, has a fleshy, spindle shaped tap root that often attains an enormous size. In adult plants, the surface of this is covered with a corrugated woody layer that hinders evaporation, while the inner tissue is stored with abundant food materials.

The propagation roots originate from various parts, more abundantly from the lower part of the vertical fleshy root, pass out horizontally for a short distance, then rise to near the surface of the ground several feet away from the mother plant, where adventitious buds are

produced. A number of young plants may have their origin in series from a single propagating root. The buds are formed only where the root has attained to the proper distance from the surface of the ground for the thrifty growth of the young plants. Each young plant, while



Root propagation of *Ipomœa leptophylla* Torr. *A*, parent plant; *B*, young plant; *C*, propagating root; *D*, ground line. Reduced to $\frac{1}{10}$ natural size.

still connected with its parent, sends down a fusiform fleshy root which penetrates the soil to a depth of three or four feet.

The accompanying figure shows the fleshy root of an old plant connected with a young plant by one of its propagating roots. This plant had six other horizontal roots that were presumably propagation roots also. It was noticed that the propagating root under consideration was thinnest at a point two or three feet away from the young plant, and that it branched back of this point, probably giving rise to propagating rootlets of other young plants. It took its origin from the mother plant about three feet below the surface of the ground.—GEORGE L. CLOTHIER, *State Agricultural College, Manhattan, Kansas.*

NOTES ON LILÆOPSIS.

MR. J. B. S. NORTON, of the Missouri Botanical Garden has just called our attention to the fact that *figs. 3* and *4* were transposed in

our revision of this genus.[2] *Fig. 3* is the fruit of *L. Schaffneriana*, and *fig. 4* that of *L. Carolinensis*, as the descriptions indicate.

Mr. Norton sends a specimen of our new species *L. Carolinensis* from New Orleans, collected by J. F. Joor. The only locality known to us was eastern North Carolina.

The eastern distribution of *L. lineata* is usually given as from Massachusetts to Mississippi, but we have never seen specimens west of Florida.

Collectors along the Gulf coast should endeavor to discover whether these two species are found there, and learn definitely their distribution. The flowers of Lilæopsis are always given as being white, but in *L. Carolinensis* Dr. Joor says they are pink.— JOHN M. COULTER and J. N. ROSE.

THE PHYSIOLOGICAL PROBLEMS OF TODAY.[3]

IF it be true that the fundamental problem of physics is the constitution of matter, it is equally true that the fundamental problem of physiology is the constitution of living matter. I think the time has come for physiology to return to its fundamental problem.

Living matter is a collective term for the quality common to all living organisms. Comparative physiology alone enables us to discriminate between the general properties of living matter and the functions of specific organs, such as the blood, the nerves, the sense organs, chlorophyll, etc. Nothing has retarded the progress of physiology and pathology more than the neglect of comparative physiology. Comparative physiology shows that secretion is a general function of all living organisms and occurs even where there is no circulation. Hence it was *a priori* false and a waste of time to attempt to explain secretion from the experiments on blood pressure. Oxidations occur regardless of circulation and it was *a priori* a waste of time to consider the blood as the seat of oxidation. Comparative physiology has shown that the reactions of animals to light are identical with the heliotropic phenomena in plants. Hence it is a mistake to ascribe such reactions as the flying of the moth into the flame to specific functions of the brain

[2] BOT. GAZ., **24**: 48, 49. 1897.

[3] Delivered at the Ithaca meeting of the American Society of Naturalists, December 29, 1897. Dr. Loeb's paper is one of seven upon "The biological problems of today," each speaker being limited to ten minutes.

and the eyes. Sleep is a phenomenon which occurs in insects and plants, and it would be a waste of time to attempt an explanation of sleep on the basis of phenomena of circulation. The best interests of physiology and pathology demand that the systematic development of comparative physiology be one of the physiological problems of today.

May I be pardoned for calling attention to one special field of comparative physiology which I believe to be especially fertile. I refer to the field of physiological morphology. I applied this name to the investigation of the connection between the chemical changes and the process of organization in living matter. Two series of facts allow us to connect these two groups of phenomena: (1) the fact that phenomena of fermentation lead to an increase in the number of molecules and thus bring about an increase of osmotic pressure in the cells, this increase of osmotic pressure being the source of energy for the work of growth: (2) the facts of heteromorphosis, *i. e.*, the possibility of transforming in certain animals one organ into another or substituting one organ for another through external influences, such as gravitation, contact, light etc.

The exact and definite determination of life phenomena which are common to plants and animals is only one side of the physiological problem of today. The other side is the construction of a mental picture of the constitution of living matter from these general qualities. In this portion of our work we need the aid of physical chemistry and especially of three of its theories; stereochemistry, van 't Hoff's theory of osmotic pressures, and the theory of the dissociation of electrolytes. We know that the peculiar phenomena of oxidation in living matter are determined by fermentative processes, and we venture to say that fermentations form the basis of all life phenomena. It has been demonstrated that fermentability is a function of the geometrical configuration of the molecule. *Saccharomyces Cerevisiæ* is a ferment for such sugars only as have three or a mutiple of three atoms of carbon in the molecule. Among the hexaldoses only δ-glucose, δ-mannose, and δ-galactose are fermentable, while their stereoisomers are not fermentable. But the influence of the geometrical configuration goes farther. Voit has suggested and Cramer has demonstrated that there is a far-reaching parallelism between the fermentability and assimilation of carbohydrates. Higher animals as well as yeast cells are able to form glycogen from such carbohydrates as are fermentable by yeast. The further development of these stereochemical relations and their extension to

proteids and nucleins is another of the problems of physiology which will contribute to the main problem, the analysis of the constitution of living matter. I believe that the influence of stereochemistry will be more or less directly felt in many branches of physiology, in questions of heredity, as well as in the theory of space sensations as E. Mach has already intimated.

In living organisms chemical energy is frequently transformed into osmotic energy. Van 't Hoff's theory of osmotic pressure permits an application of the law of conservation of energy to a class of phenomena to which this law was hitherto inapplicable, namely the phenomena of growth, functional adaptation, secretion, absorption and even pathological processes such as œdema. The physiologists who thought that the blood pressure determined secretion could not understand why secretion took place under a higher pressure than the blood pressure. Comparative physiology shows that secretion does not depend upon circulation, and the theory of osmotic pressure indicates that the osmotic pressure in the cells is more than twenty times as high as the blood pressure. The work of secretion is done by osmotic pressure and not by blood pressure. A prominent physiological chemist has become a vitalist because he could not explain why the secretions differ from the blood from which he thinks they are formed. He overlooks among others the fact that the protoplasm possesses the quality of semi-permeability, which means that it allows certain substances to pass through and others not. In my opinion the working out of a theory of semi-permeability is one of the main physiological problems of the day.

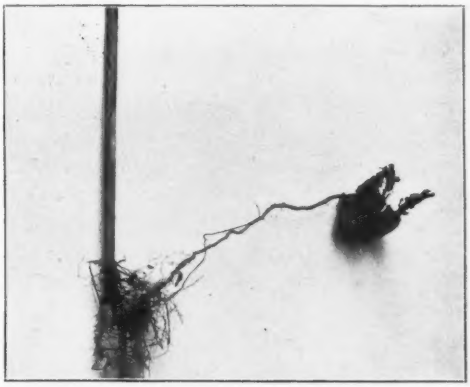
The theory of the dissociation of electrolytes is of fundamental importance in the analysis of the constitution of living matter. Pharmacology will feel its influence most directly. Everything seems to indicate that the specific physiological effects of inorganic acids are due to the number of positively charged hydrogen ions in the unit of solution, and the specific physiological effects of alkalies to the negatively charged hydroxyl ions. But the universal bearing of the theory of dissociation upon physiology will perhaps be best seen in the field of animal electricity. An active element of living matter in a state of rest is negatively electric to its surrounding parts. We may assume that an acid is formed in the active part and that the passive parts are neutral. The positive hydrogen ions of the acid have a much greater velocity of migration than the anions. Hence the former will

diffuse more rapidly into the passive tissue than the anions, and the active tissue will remain negatively charged.

At no time since the period immediately following the discovery of the law of conservation of energy has the outlook for the progress of physiology appeared brighter than at present. But in order to reap the full benefit of our opportunities we must bear in mind that the fundamental problem of physiology is the determination of the constitution of living matter, and that in order to accomplish our task we must make adequate use of comparative physiology as well as physical chemistry. Pathology, in particular, will be benefited by such a departure. — JACQUES LOEB, *The University of Chicago.*

APHYLLON LUDOVICIANUM ON AMBROSIA TRIFIDA.

I HAVE found the Louisiana naked broomrape to be one of the rare plants in this vicinity; but when found it has always been attached to



the roots of the great ragweed. The roots given out by the host, which connect the two plants, are at first small, so that it is almost impossible to trace them to their destination. But they steadily increase in size, until they are often as large as a wheat straw by the time the parasite has run its course, which is usually about the last of September. There is usually only one supply-root, and this is of nearly the same size its entire length, and a mat of small haustoria is

developed by the guest at the point of contact. The parasitism appears to be complete, as the broomrape has no soil roots.

Perhaps the reason for the existence of some discrepancy and uncertainty as to the real host of some of the species of the broomrapes is due to the fact that they have not been kept under observation until the parasite had matured and withered.

The accompanying cut, made from a photograph and reduced to one-fourth natural size, shows in a striking manner how the one root of the ragweed has grown at the expense of the rest.—J. SCHNECK, *Mt. Carmel, Ill.*

BIDENS CONNATUS MÜHLENBERG.

IN THE year 1874 I found on lake Ruppin a form of Bidens, distinguishable at a glance from our two indigenous species (*B. tripartitus* and *B. cernuus*) by its basal bushy branching, the light green color of its almost always undivided stem-leaves narrowed into a short petiole. Upon closer observation I found that the involucral bracts of the flower heads were mostly in fives, always non-ciliate, and longer than in *B. tripartitus*. Moreover the mature fruits always have four awns and the epidermis rather large warts (Höcker). These peculiarities led me to characterize this form (in *Verhandl. des bot. Ver. der Prov. Brandenburg* **1879**: 157–158) under the name *B. tripartitus* L. var.? *fallax*.

Since then, chiefly on account of my bryological studies, the plant has not come to my notice, until it turned up again in the autumn of 1895 on raft-logs in our lake. Of course I recalled having seen and remarked it many years before, but my especial notice of it in 1879 had entirely escaped my memory; thus it happened that after a thorough investigation, laying more stress upon the specific value of the warty four-awned fruit, I published it (in *Œsterr. bot. Zeitschrift* **45**: 392, 1895), as *B. decipiens*.

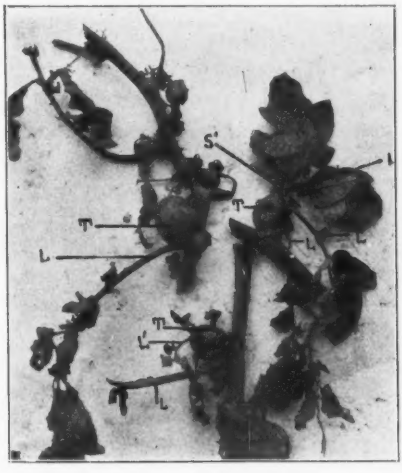
Meanwhile, my long-time friend Professor Dr. Ascherson of Berlin, who had become interested in the plant, made an examination of the Berlin Botanical Museum and referred our plant, by Mühlenberg's type specimen, in Willdenow's herbarium under no. 15,021, to *B. connatus*. The matter would have been thereby settled had I not already received from various parts of North America as *B. connatus* an entirely different plant. In this the fruits are always smooth and usually two-awned, only occasionally having a shorter median awn. They are, thus, just

like those of *B. tripartitus*. On this account the specimens from the United States heretofore seen by me cannot possibly be identified with Mühlenberg's type in the Willdenow herbarium, but belong to another good species.

It would be of great phytogeographic interest if the botanists of the United States would observe, now in their herbaria and next season in the field, whether *B. connatus* really occurs there with warty four-awned fruits, as in Europe, or whether this plant is there found only with smooth two to three-awned fruits. Perhaps there can be found in some of the older herbaria Mühlenberg's types, which might show whether the fruits are smooth or warty, two- or four-awned. In any case I should be greatly obliged for information on this point.— C. WARNSTORF, *Neuruppin, Germany*.

AERIAL TUBERS OF SOLANUM TUBEROSUM.

IN December 1895, some interesting specimens of aerial tubers were found on *Solanum tuberosum* in the garden of the steward of the



Louisiana State University and Agricultural and Mechanical College, at Baton Rouge. My attention was called to them by Mr. Holmes,

the steward. The plant had no well developed underground tubers, but the stem above ground had developed on it upwards of fifty well formed tubers, varying in size from a half inch to two inches in diameter. Nor were they confined to the portion of the stem near the ground, but extended up the stem almost to the top. It is true the stem was not erect, but it was not more prostrate than others about it. The tubers were located in the axils of the normal leaves. In some instances there was only one tuber in the axil of the leaf, in others there were more, and in one case there were five. These tubers were of the shape and size of those ordinarily formed underground, but in many instances the leaf-scale of the normal potato was here developed into a large foliage leaf, which did not differ from the normal leaf of the stem. The tubers contained a large amount of chlorophyll, but were not as green as the stem. In most cases where leaves were developed on the tubers the bud in the axil of the leaf did not differ from the "eye" of the underground potato. In one or two instances, however, a branch was developed which, in turn, had three or four leaves. The cut shows one of these stems with its leaves, *L* marking the normal leaf, *T* the tuber in its axil, *L'* the leaf on the tuber. The stem to the right shows the secondary stem from the tuber, marked S'.

The plant grew in the open garden, and, so far as light and moisture were concerned, was not different from hundreds of others that surrounded it. The tubers were preserved and planted in the following spring, but they were very late in sprouting, and some of them rotted without sprouting. Those that produced plants were caught by the hot dry summer, and were attacked by blight before they came to maturity. The plants did not look different from those produced by the ordinary tubers.

Copies of the accompanying photograph were sent to several botanists, who regarded this as an unusual occurrence, though several had seen something like it before. After dismissing the subject for nearly two years, I again came across the photographs, and decided the matter was of sufficient interest to be placed upon record.— W. R. DODSON, *Baton Rouge, La.*

CURRENT LITERATURE.

BOOK REVIEWS.

A text-book of general botany.

THE MAKING of a book is now looked upon as almost reprehensible, and the writer is mentally challenged by his fellows to show valid reason for its publication. The new *Text-book of general botany*[1] must answer this challenge, which is the more peremptory in view of the large claim made by a title devoid of any limitation.

We turn to the preface to learn what the author has to say in justification of his book and the standards by which he wishes it judged. We are told that "the work is intended as an introduction to the study of botany"; and that "the text is based upon the laboratory work required of beginners at Columbia of which it is but an exposition, being supplemented by an extended course of lectures and prescribed reading." In view of its introductory character, would it not have been well to select a title less comprehensive, one by which the book might be more justly designated?

The statement regarding the relation of the book to the work prescribed for beginners in Columbia University is of much interest from a pedagogical standpoint. In order to understand this, it must be said, that, after presenting a group of facts, Dr. Curtis gives general directions for laboratory examination of plants illustrating them. Accompanying this is a list of reference books, in which, presumably the prescribed reading is assigned. The laboratory outlines cover the subjects of histology, physiology, and morphology, and involve the use of material in large amount, which, we infer from the preface, each student is expected to collect and prepare for himself. We are utterly unable to reconcile this amount of work with the amount of time allotted for its performance, viz., two mornings per week for one year—at most 300 hours! Dr. Curtis must have students with extraordinary powers of accomplishing work if *half* that here laid out is really done in a year. Does he realize that he has called for nearly sixty histological preparations, over thirty physiological experiments, and a more or less complete morphological examination of about one hundred plants? In this reckoning we have included as two plants such a direction as this:

[1] CURTIS, CARLTON C.: A text-book of general botany. Large 8vo. pp. viii + 359; figs. 87. New York: Longmans, Green & Co. 1897. $3.

Compare *Marsilea* and *Isoetes* with *Pteris*. Do they differ as to growth, branching and leaf arrangement? Which has the highest type of leaf and stem? Has each the homologue of the sorus, indusium, sporangium and annulus? Are the sporangia situated as in Pteris? Is the arrangement of the two kinds of spores the same in both genera?

How many hours will that take? And how many, the comparison of Equisetum with Pteris, requiring eight microscopical preparations (of which five are sections) besides observation of the external anatomy? That such directions may be useful we readily concede; but that anywhere they can be carried out in 300 hours, or 600, we must seriously doubt.

It goes without saying that one in Dr. Curtis' position, with adequate facilities at his command, is capable of enumerating the chief facts of botany when he sets about it; accordingly we find in this book a fairly accurate and up-to-date account of plant structure and phenomena. The facts are made coherent by a thread of philosophical theory which stimulates thought on the part of the student and leaves him with an open mind. The book may therefore serve a good purpose as a reference book in laboratories, particularly as it is well illustrated by new figures.

A most important consideration in a work for beginners is the presentation of the subject. As to manner, this is somewhat unfortunate. Dr. Curtis' English syntax is not above reproach, and his use of words is frequently inelegant or even incorrect. As to matter, it may be questioned whether histology is well adapted for introducing the beginner to the science of botany. What advantage has it over "analysis" which we all decry? Ought not the student's first impression of the plant rather be of an *organism*, capable of *doing* something? Has he at the outset any knowledge which can illuminate the details of histology and make them interesting and intelligible? If it be replied that the student must know structure before he can understand function, it is granted; yet his knowledge of structure must not be deadened by study of detail, it must be vivified study of action.

Through these considerations we are led to the conclusion that the book before us is a convenient compendium of the well-known facts of botany and a laboratory guide with useful suggestions as to illustrative material. In these things it is no better than its predecessors; and this, together with some faults in plan and execution deprive it of a valid *raison d'être*.—C. R. B.

A manual of botany.[2]

THE first edition of this valuable manual appeared in 1895, being intended to take the place of Bentley's *Manual*. In fact, it was the original intention to

[2] GREEN, J. REYNOLDS.: A manual of botany. In two volumes, 2d edition. Vol. I. Morphology and Anatomy, xii + 406. *7s 6d*. Vol. II. Classification and Physiology, xi + 541. *10s*. J. & A. Churchill: London. 1897.

make it the sixth edition of that work. The necessity for a second edition in two years speaks well for its usefulness. It is well named a "manual," making no claims as a text-book prepared for any special class of students. In an orderly and very clear way it presents the main facts of the subject, in many parts largely partaking of the dictionary style, which is allowable in a manual. The part which treats of morphology bears the most ancient stamp, being simply Bentley's presentation modified sufficiently to include newer views. In the second edition this is still further revised. The part which treats of classification (407 pages) follows the usual method of treating the thallophytes, bryophytes, and pteridophytes from the morphological standpoint as the basis of a rational classification, and the spermatophytes from an entirely different standpoint. This unfortunate group is presented with its usual dreary list of cohorts, orders, etc., entirely unreadable, and suited only to a strictly taxonomic work. Mr. Green, however, is but following the usual custom.

In the parts devoted to anatomy and physiology, however, the author appears at his best, for he is in his own field, and one can recognize the touch which has come from personal contact. It seems to us that the chapters on physiology give us the best brief presentation of that great subject which we have met. Compressed as it is into 116 pages out of a total of 947 it is surely entirely out of all proportion. Gladly would we have contributed to its fuller expansion the 220 pages (!) of Benthamian cohorts and orders. We can do little more than give the titles of the chapters which deal with physiology, but even the titles are very suggestive of the treatment. They are as follows: The relation of water to the protoplasm of the cell, the transport of the water in the plant, the skeleton of the plant, the transpiration current (with root pressure and transpiration), the food of plants, the absorption of food materials by a green plant, the chloroplastids and their function, reserve materials, the catabolic processes, the respiration of plants, growth, influence of the environment on plants, the relation of the plant to its environment (with irritability), special sensitiveness and its results, the nervous mechanism of plants, automatism (with rhythm), reproduction.—J. M. C.

Botanical notebook.[3]

THE second edition of this little book has been entirely rewritten, and gives us a good glimpse of the botanical instruction at Brown University.[1] It treats of plants in much the same way as they are presented in Gray's text-books, namely, the gross morphology of spermatophytes. For those

[3] BAILEY, W. W.—Botanical notebook, a synopsis of lectures and laboratory plans in general morphology and systematic botany for use in classes in Brown University. Second revised edition. 8vo. pp. xi + 120. Preston & Rounds Co.: Providence. 1897.

who have had no contact with botany this is better than an exclusive use of the compound microscope, but in so far as it suppresses an examination of the lower groups it is incomplete from its own standpoint. The endless lists of names, serviceable only in taxonomy, are not of great educative value: but for those bent upon "analyzing" flowering plants they are a necessary antecedent. We have regarded this phase of botany, so far as elementary students are concerned, as holding the same relation to the science of botany as does the collecting of postage stamps to the science of geography. It is very interesting, and hence very attractive, but it is hardly botany as we understand it today. However, for those who want to do this sort of thing Professor Bailey's book is a most excellent guide, and it suggests some capital work for secondary schools after the pupils have reached the spermatophytes.—J. M. C.

Practical botany.

THE extensive use made of Professor Strasburger's *Das botanische Practicum*, both in the original and in translations, and in the complete and briefer forms, is evidenced by the numerous editions. It is unusual for a laboratory guide to keep so nearly abreast of current knowledge. A third edition of *Das kleine botanische Practicum* is before us.[4]

As the title indicates, the book is intended primarily for those who are unable to study in the schools under a teacher. It is presumed that the pupil is acquainted with the more recent text-books of botany, and that he has sufficient familiarity with plants to enable him to collect material.

As in the preceding editions, there are thirty-two lessons, but the number of studies under each lesson has been considerably reduced upon the theory that it is better to have a thorough knowledge of a few forms than a superficial knowledge of many. The types considered are about the same as in the last edition, but the exercises have been revised to keep pace with the increasing information on the various subjects. The lesson on bacteria has received special attention. The modern methods of investigation are given in detail, and the form, structure and development of the bacteria are more fully treated than in the previous editions.

On the whole there is an improvement in the technique, the literature also has been brought up to date, and the very complete index adds materially to the value of the book.

The figures are all from Strasburger's own drawings, and nearly all the work, even when it deals with well-known subject-matter, rests upon the author's own investigations.—C. J. C.

[4] STRASBURGER DR. EDUARD: Das kleine botanische Practicum für Anfänger, etc. Dritte umgearbeitete Auflage. 8 vo. pp. 246. 121 cuts. Jena: Gustav Fischer. 1897. In paper *M* 6, bound *M* 7.

Exercises in botany.[5]

THIS little book, the author states, is designed to supply the need of pupils under the supervision of a teacher who can devote but little time to the subject, and is planned so that the teacher, burdened with other duties, need have little to do in the way of preparing outlines of the daily work. It contains many suggestive facts and various interesting observations not found in similar books. The colloquial and figurative style, which the author adopts to a considerable extent, doubtless aids in holding attention, but seems, at least here and there, to be carried beyond permissible limits in a work devoted to scientific teaching, as, for instance, when it is stated that the embryo of the western peony "does not intend to carry its store of food above ground, ... nor does it risk decapitation at the hands of Jack Frost." In some cases there is more or less obscurity, as in the question, "Which edge of an elm leaf is nearest the twig on which it grows?" And we are reminded of Grant Allen's "high priori" reasoning by the passage, "In short, an apple is good that its seeds may be distributed. A cherry is red that some cherry-loving animal may surely find it and drop its seed far from the parent tree."

On the whole, it may be doubted whether the book is likely to quite fulfill the author's purpose, and a careful examination strengthens the conviction that, however such books may be multiplied, the need of specially trained teachers is thereby increased rather than diminished. In the teacher's library, with others of its kind that are appearing at frequent intervals, it will serve a good purpose in suggesting observations and experiments.—V. M. S.

NOTES FOR STUDENTS.

PROFESSOR D. H. CAMPBELL,[6] has recently investigated the morphology of Naias and Zannichellia. He has confirmed the views of previous observers as to the axial nature of the stamens and ovules, and the mutual relation of leaf, axis, and branch. The stamen of *N. flexilis* is interesting on account of its being surrounded by two envelopes, the inner of which Professor Campbell regards as the homologue of the ovular integument which it greatly resembles, and the outer as corresponding to the carpel of the "female flower." The origin and development of the sexual elements, the growth of the pollen tube, and fertilization do not depart materially from the usual angiospermous type.

The first division of the embryo is transverse, as usual, dividing it into a basal or "suspensor" cell and a terminal or "embryo" cell. The further development of the embryo agrees with Schaffner's account of Alisma as

[5] RATTAN, VOLNEY.—Exercises in Botany for the Pacific States. The Whitaker & Ray Co., San Francisco. 1897.

[6] Proc. Cal. Acad. Sci. 3d series 1 : 1–62. *pl.* 5. 1897.

opposed to Hanstein's. The suspensor cell enlarges considerably, but remains undivided, and all the embryo and the secondary suspensor cells are derived from the embryo cell which first becomes divided transversely into a number of segments. In *N. flexilis* the terminal segment of the row thus formed gives rise to the cotyledon, the second to the stem, and the third and fourth to the root. In Zannichellia the terminal segment divides vertically, one-half becoming converted into the cotyledon, and the other into the stem, the second, third and fourth segments give rise to the root, and the fifth to the root-cap. The embryo of *N. flexilis* is peculiar in having no trace whatever of a root-cap; that of Zannichellia in the terminal origin of the stem.

The endosperm in both genera is rudimentary. In the later stages of the embryo-sac of *N. flexilis* there is always present near the antipodal cells a large nucleus which increases to an enormous size but does not undergo division. Since Professor Campbell did not succeed in demonstrating a fusion of the polar nuclei, he is inclined to doubt whether such a fusion takes place, and to regard this large persistent nucleus as one of the unfused polar nuclei. As an alternative explanation he suggests the possibility that this large nucleus may be one of the two originating from the first division of the definitive nucleus. The correctness of the latter explanation would seem to be indicated by the presence in Zannichellia of a similar large nucleus, although fusion of the polar nuclei probably occurs, as well as by Schaffner's observation[7] that in *Sagittaria variabilis* there are only two or three derivatives of the lower endosperm nucleus and these enlarge enormously.—W. R. S.

ITEMS OF INTEREST on the subject of insect pollination are given by E. Ule.[8] Observations, made chiefly in Brazil, indicate that *Asclepias Curassavica* is usually pollinated by *Danais Euripus*, "a large red-brown spotted butterfly," whose wings resemble in color the flower of the Asclepias. It is said that this butterfly rarely visits other flowers, though large numbers of nectar-bearing flowers are often found in the same locality. Other butterflies frequently seen in this locality very rarely visit this particular species; but when visiting it were seen to load themselves with pollen just as the *Danais Euripus*, and probably bring about pollination with equal effectiveness though in a smaller number of cases. It is also said that this butterfly has been a constant companion in the migrations of this milkweed as it has spread from America. The caterpillars of the butterfly live and feed upon the plant, but seldom cause any injury to it.

The author cites the above as a case of symbiosis, under the category of mutualism. The Asclepias is pollinated and pays for the favor by giving

[7] BOT. GAZ. **23**: 267. 1897.

[8] Ber. der deutsch. bot. Gesellschaft **15**: 385–387. 1897.

resting place and food both to the butterfly and its offspring, the caterpillar. Just how far the term symbiosis is to be extended is becoming quite a question. If the above happy case of reciprocity is a true case of symbiosis, we must extend the application of the term to the conditions existing between certain groups of animals and plants. And if we extend it to this we shall be well on the way toward saying that the relations between plants and animals at large give us a gigantic illustration of symbiosis. There are many who are disposed to limit the term symbiosis to those more intimate relationships of organisms, cases of actually living together, the "commensaux" condition. As to how far the term shall be extended to those cases where organisms are dependent upon each other for a brief period, mutually or otherwise, becomes a question of degree rather than content.—O. W. C.

AN IMPORTANT contribution to the bacteriology of plant diseases has been made by Dr. Erwin F. Smith [9] in a study of brown rot in various cruciferous plants, especially in turnips, cabbage, and kale. A yellow, motile germ, of micrococcus-like appearance, has been isolated and its behavior in the laboratory under various conditions tested. It is aerobic, produces no gas or acid, and forms no spores.

In the cruciferous host it is chiefly found along the fibro-vascular bundles, especially in the vessels, and brings about a characteristic brown discoloration not shown when grown upon other media. A very interesting observation was made in reference to its dispersion within the host. It travels along the vascular strands with readiness, but passes from one to another through the intervening parenchymatous layers with difficulty. The inhibitory condition appears to be due, in part at least, to the acidity of the parenchymatous sap, the organism preferring the alkaline fluids of the bundles.

Many interesting, novel and important details of the study cannot be even alluded to in this connection. The work has established beyond any seeming possibility of cavil another marked disease of plants caused by parasitic bacteria.

The natural infection appears to be through the leaves, partly by the gnawing of worms and insects, and partly by the entrance of the germs through the water pores when root pressure fills them with sap. The disease is apparently widespread, and of considerable economic importance. It does not break down the tissues to any marked extent, but beside producing a discoloration it checks the growth, and often causes the leaves to yellow and drop, making the crop a failure. There is a curious omission of reference to the researches of Dr. H. L. Russell on this disease, some of which have already been published, as well as to those unpublished of which Dr. Smith

[9] SMITH, ERWIN F.—*Pseudomonas campestris* (Pammel), the cause of a brown rot in cruciferous plants. Centr. f. Bakt. Par. u. Infekt. 3: 284–291, 408–486, *col. pl. 6.* 1897.

was fully cognizant. We reserve further comment upon this matter until the publication of Dr. Russell's paper, of which advance sheets have reached us. —J. C. A.

THE *Journal of Botany*[10] has reprinted from the 15th Ann. Rep. of the Fishery Board of Scotland some observations by Mr. George Murray on the plankton of the west coast of Scotland. Mr. Murray finds the bulk of this free-floating vegetation to consist of about ten species of diatoms and a few Peridineæ. In the early months of the year diatom life prevails, reaching its maximum aboat the first of April; in the latter part of the year Peridineæ forms predominate, culminating in August. During the entire year the most favorable zone for diatom development was at a depth of five fathoms, with the prominent exception of *Skeletonema costatum*, which was practically confined to the surface in March and April. Mr. Murray's observations go to prove that small crustacea live almost entirely upon diatoms. Such species as have spines, and the Peridineæ forms, do not serve apparently as daily food for the lower forms of animal life. Besides the ordinary division and the formation of auxospores, reproduction of diatoms by means of endogenously formed spores or endocysts was observed. In some cases as many as sixteen of these reproductive bodies were produced in one diatom, and in summer they were found with unsilicified membranes, dissociated from the parent and undergoing further division. Later in the season forms like the parent reappeared.—H. W. L.

L. A. GAYET[11] has recently completed a monograph on the development of the archegonium in the bryophytes. The article occupies about one hundred pages and sets forth the results of six years' work. A few of the most important points are as follows. The terminal cell, often called the cover cell, contributes to the growth of the neck of the archegonium in the Hepaticæ as well as in the Musci, although the terminal cell is much more active in the latter. The terminal cell does not give rise to neck canal cells either in the Hepaticæ or Musci, but all the neck canal cells are of the same origin, and come from an initial detached from the mother cell of the oosphere. There are also observations on the pedicel cell, the number of neck canal cells, and the number of longitudinal rows in the neck. There are occasionally two ventral canal cells in Sphærocarpus. In one case the ventral canal cell of Marchantia was fertilized instead of the oosphere.

The development of the archegonium of the Anthoceroteæ is so different from that of other bryophytes that the author makes the Anthoceroteæ a group coordinate with Hepaticæ and Musci, and places it, not in its usual

[10] Jour. Bot. **35**: 387–395. 1897.

[11] Recherchés sur le developpement de l'archegone chez les Muscinees. Ann. Sci. Bot. VIII. **3**: 161–258. 1897.

position just preceding Musci, but between the Musci and pteridophytes. He believes that the group is more nearly allied to the pteridophytes than to the Hepaticæ.

An artificial key to the Hepaticæ, Musci, and Anthoceroteæ is given, based entirely upon archegonium characters. This recalls Treub's effort to base a classification upon chalazogamy.

No mention is made of Campbell's recent book upon mosses and ferns, although quite an extensive bibliography is given. A perusal of this book would probably have added to the value of M. Gayet's monograph.—C. J. C.

WIESNER has made another valuable addition to his various studies on the influence of rain on the plant world. Readers of the GAZETTE will remember in this connection his studies on ombrophilous and ombrophobous organs.[12] His latest work has been to observe the mechanical influence of rain on plants.[13] After referring to the researches of Jungner and Stahl on the adaptations of tropical leaves to rain, the author refers to the common view among botanists that rain works mechanical injuries on plants, although this view is based wholly on theory rather than on actual experimentation.

Wiesner found that the heaviest rain drops, whether in or out of the tropics, weigh but 0.16^{gr}, and that the greatest velocity attained is but 7^{m} per second. Hence the "greatest living force" possible is but 0.0004^{kgm}. Rarely more than six heavy drops fall per second on a space of $100^{sq\,c}$. Water poured from a watering can so slowly as to strike the ground in drops has from fifty to one hundred times this force. The author then records experiments on leaves and flowers and finds, for example, that the corolla of *Impatiens noli-tangere*, when placed on a firm support, is injured by a sphere of lead weighing one gram falling 4^{cm} ($=0.000004^{kgm}$); while swinging free in nature it requires a force of 0.08^{kgm} to produce an injury, *i. e.*, a force 20,000 times as great, and a force 200 times as great as that exerted by the severest rain! Similar results are obtained from all experiments, so that the author concludes that leaves and flowers are practically never mechanically injured by rain alone where swinging free in nature. This conclusion might be reached *a priori* from the fact that tropical leaves, which are exposed to more rain than plants of our latitude, are nevertheless less adapted to stand mechanical injury; for example, they absorb water more freely, thus becoming less protected from mechanical impact, and even when dry they are more readily perforated than our ordinary leaves.

While rain produces little or no mechanical injury when unaccompanied by wind, the destruction due to wind and rain combined is quite patent, but although the water may here do actual mechanical harm, the wind rather

[12] BOT. GAZ. **20**: 112. 1895.

[13] Untersuchungen über die mechanische Wirkung des Regens auf die Pflanze. Ann. Jard. Bot. Buit. **14**: 277–353. 1897.

than the rain is to be regarded as the real cause. The rain of itself produces injury, not mechanical but of a secondary nature; the fall of leaves several hours after a rain may be regarded as due to the fact that the organic separation of the leaf from the tree is hastened by the increased turgescence caused by the rain.—H. C. C.

A RECENT PAPER by Kny[14] confirms the earlier work of Boussingault and Jodin, in affirming a close dependence of the chlorophyll function upon the living plastid and the cytoplasm. The author used as test fluids various blue solutions which had been decolorized with sodium hydrosulfite. Any free oxygen which might be present was driven off by heating, and the liquid again decolorized. This precaution had apparently been neglected by Regnard, who had employed similar methods. Engelmann's bacteria test was also used, this being a very delicate indicator of the presence of oxygen.

In studying chlorophyll separated from its living matrix, its solution in olive oil, or dried into absorbent paper, was used, also portions of plants killed by scalding or drying. All the tests agreed in finding no oxygen liberated during isolation. The results of experiments upon living chloroplastids removed from cytoplasm do not agree with those obtained by Engelmann, Haberlandt, and Pfeffer. Plastids from plants liberated oxygen in no case except where cytoplasm was adhering to them.

Certain external influences were next applied in order to note their comparative effects upon the cytoplasm and chlorophyll function. Plasmolysis did not stop the activity of chlorophyll as long as the protoplasm showed no plain sign of dying. Electricity, moderately applied, had a stimulating effect. Tapping upon the object under the cover glass gave varying results. The ability of plastids to resume activity after having been dried depended on the life habits of the plant, lichens and mosses showing a marked contrast to spirogyra, for example. A temperature of about 50° checked the work of photosyntax before the cytoplasm and chromatophore were perceptibly altered. By shortening the time of exposure sufficiently, these last results were practically reversed. Chloroform affected cytoplasm and chromatophore before the chlorophyll function was checked. The same thing was observed when weak solutions of ammonia and of nitric acid were applied. The general conclusion from these experiments is that the injury to the chlorophyll function does not proceed parallel to that of the cytoplasm and nucleus.—W. D. M.

[14] Die Abhängigkeit der Chlorophylfunction von dem Chromatophoren und vom Cytoplasma. Ber. d. deutsch. bot. Gesells. **15**: 388–403. 1897.

NEWS.

THE ATTENTION of contributors is called to the new regulations concerning separates, which are announced in this number of the GAZETTE.

MR. B. E. FERNOW, Chief of the Division of Forestry, has been called to Hawaii to make a reconnoissance and to report concerning desirable forestry legislation.

MR. FRANCES RAMALEY, Instructor in Pharmaceutical Botany, in the University of Minnesota, has been appointed Assistant Professor of Botany in the University of Colorado, Boulder, Colo.

PROFESSOR G. F. ATKINSON has been experimenting upon plants with the Röntgen rays, and has published a preliminary report in *Science* (January 7). No conclusions are reached, as might be inferred from the following statement: "The longer my experiments continued the more mysterious the whole subject seemed."

THE proposed "Society for Plant Morphology and Physiology" was successfully organized at Ithaca at the recent meeting of the American Society of Naturalists and affiliated societies. A full account of this meeting, both as to the organization of the society and as to the papers read, will appear in the February number of the BOTANICAL GAZETTE.

THE COLLECTION of plants and literature made by the late Professor L. N. Johnson, of Ann Arbor, are offered for sale. Professor Johnson was especially interested in algæ, particularly the desmids, and had published a number of papers concerning them. The writer has inspected the list of books and papers and finds the alga literature well represented.

IT IS reported in *Science* that ground was formally broken for the museum building of the New York Botanical Garden, on December 31. The contract for the construction and equipment of the museum building, power-house, and minor buildings, has been awarded for $347,019. The plans for the great range of horticultural houses have been completed, and specifications for them have been printed. During the past season about 2900 species of plants have been obtained, together with large quantities of museum, library, and herbarium material.

THE PRESS REPORTS of the burning of Pardee Hall at Lafayette College stated that the entire collection of Dr. Thomas C. Porter had been destroyed.

A private letter from Dr. Porter informs us that the greater portion of the collection was saved, but with a good deal of damage from fire and water. An immense amount of labor will be necessary to prevent further loss and to bring order out of confusion. The separate collections from Pennsylvania were not seriously injured, so that Dr. Porter will not be hindered in the completion of his *Flora* of the state. The loss in the botanical library was considerable.

THE COMPLETE HERBARIUM of the late Mr. M. S. Bebb has been purchased by the Field Columbian Museum of Chicago, including his letters, manuscripts, sketches, drawings, etc. The material of Mr. Bebb's own collecting was always known for its perfect preservation, but aside from the large general collection the special value of this purchase is to be found in the unique collection of Salix material. The botanical department of the Museum, under the direction of Dr. C. F. Millspaugh, is to be commended for its enterprise in securing collections which will soon make it an important taxonomic center.

AT THE MEETING of the Minnesota Academy of Science, at Minneapolis, December 28–30, 1897, three botanical titles were presented. Professor J. C. Arthur read a paper on "The law of regression in plants," dealing with the tendency of plants to approximate toward mediocrity in size of seed and vegetative body. Professor MacDougal read a paper on the "Development of saprophytism," in which two general methods of variation toward the greater use of organic food were outlined, and another on the "Problems and province of plant-physiology," in which the present status of the subject in teaching and research was discussed.

WE note with regret that with the number (December 29) which completes its tenth volume, *Garden and Forest* suspends publication. The following statement is made: "For ten years the experiment has been tried of publishing a weekly journal devoted to horticulture and forestry, absolutely free from all trade influences, and as good as it has been possible for us to make it. This experiment, which has cost a large amount of time and money, has shown conclusively that there are not persons enough in the United States interested in the subjects which have been presented in the columns of *Garden and Forest* to make a journal of its class and character self-supporting. It is useless to expend more time and money on a publication which can not be made financially successful, and must, therefore, sooner or later cease to exist." This comes as a surprise to the many botanists who had come to regard this as one of their most valued journals.